T-Shaped Professionals

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Adaptive Innovators

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Abstract

This book provides a wide range of perspectives around the thesis that going forward the world will need more T-Shaped Professionals who are adaptive innovators. Skills are one of the hallmarks of every profession. The skills of doctors allow them to heal others, while the skills of lawyers allow them to seek justice for others. What types of skills should adaptive innovators possess? More specifically, what types of skills should future-ready adaptive innovators have to allow them to thrive in the age of accelerating change? We invite the reader to explore this question from the perspective of individuals, educators, practitioners, and those in government, as well as those trying to measure more precisely just what it means to be a T-Shaped Professional and adaptive innovator.

Keywords

adaptive innovators, breadth, co-creation, communications, co-production, depth, design theory, empathy, future-ready talent, problem-solving, service innovation, skills, teamwork, transdisciplinarity, T-shaped - professionals, value

Contents

Preface

A book is a good way for a community to take stock of what kind of progress has been made wrestling with a challenging problem. What skills do innovators need to be successful? In a rapidly changing world with more and more knowledge siloes, each adding new knowledge at an incredible pace—truly there is a need for adaptive innovators, who can change with the times, and assemble and work well on teams—both small and large.

Since it was founded in 2012, the International Society of Service Innovation Professionals (ISSIP, see http://issi.org) has run and/or co-sponsored conferences, bringing together speakers and participants with an interest in better understanding the skills needed by innovators. This book is based on a call for chapters that was sent out to participants of those earlier conferences and workshop. We provide a summary of that call-for-chapters (CFC) here.

To create this book we invited scholars and professionals with expertise in all areas of T-shaped skills and knowledge for talent development to consider writing a short paper/chapter. The original goal to create a platform for knowledge creation, dissemination, and practice for the under-served professional education market of service mindset for the 21st century. Both academic and industry perspectives on T-shaped talent as a framework to develop the next generation workforce. As we face ever-increasing challenges and complexity in the public and private sectors, interdisciplinary collaboration skills distinguish T-shape professionals who can navigate disruptive shifts in business, technology, and society. To capture the latest thinking, experiences and results, and to publish a collection of practical, focused, easily digestible short papers in the increasingly important area of T-shape talent development, which integrates a variety of disciplines—

including areas in engineering, social sciences, and management—to focus education, research, and practice on an expanding innovation economy. The ISSIP BEP T-Summit collection aims to offer insights and practical wisdom easily applicable to the workplace. The context in which service is designed, delivered, and experienced has been changing fundamentally, with exponentially growing and evolving technology-enabled, service transformations and innovations (e.g., IBM, Rolls-Royce, Amazon, Google, Lego, Disney, Tesco, iTunes, Uber, Smart Phones, Etsy, AirBnB, eBay). Potential beneficiaries of these books include executives and middle managers-professionals and practitioners who are seeking either to acquire new skills or refresh and update their knowledge of existing ones, and advanced business, MBA & EMBA students.

Questions that we continue to seek better and better answers to include:

- What is a T-shaped professional? What institutions hire T-shapes? What institutions create T-shapes?
- How and why do T-shapes make the best adaptive innovators? The best entrepreneurs? The best life-long learners?
- Breadth and depth of knowledge, skills, and competencies, combined with 21st Century mindset, and knowledge of self and others in large co-creation networks.
- Transformational change of education to create graduates and lifelong learners with T-shaped skills.
- Project-based and experiential learning, with industry-academic-government-and-professional-association collaboration and badges.
- 21st Century (Cognitive Era) mindset, how success is determined more by what we can do with our knowledge, than simply how much we know.
- What is a T-shaped mindset? How does empathy, growth mindset, design thinking, systems thinking, service thinking combine in T-shapes?
- How early should education begin cultivating T-shaped mindsets

in students? How best can it be done at different ages and skill levels?

- What simple and sophisticated faculty best practices can help students learn teamwork?
- What do industry practitioners need to do to help cultivate and mentor T-shaped students and peers?
- What public policy can help promote the transformation needed in education, industry, government, and professional associations to promote T-shaped development?
- What can students do to develop at T-shapes, and help their institutions and network better evolve toward and embrace the T-model?
- Other T-shaped related topics and questions.

In the end, only a fraction of chapter proposals could be accepted and assembled into this short book. We hope readers find this book a thought provoking springboard for advancing their understanding of T-Shaped Professionals as adaptive innovators. We also invite those readers who want to continue the conversation on this topic to join the community of Adaptive T-shaped Innovators at the International Society of Service Innovation Professionals, ISSIP, www.issip.org.

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April 18, 2018

Acknowledgments

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PART I

Individual Perspective

CHAPTER 1

Introduction: Toward an ISSIP T-Shaped Curriculum and Research Framework

The International Society of Service Innovation Professionals (ISSIP, see http://issip.org) is a nonprofit professional association established in 2012 to provide an umbrella professional association for students, faculty, practitioners, policy makers, and others interested in advancing service innovation as a set of methods, techniques, and tools used within a community of practice. The ISSIP "umbrella" was in full recognition and acknowledgment that service innovation was studied, in some form, across a wide range of academic discipline areas including engineering, management, operations, marketing, computing, design, social sciences, and others. The need for T-Shaped Professionals arises because service innovation is a team sport, and each individual member of the team is deep in at least one area, and also has the ability to understand and collaborate with individuals deep in another area. This depth and breadth across different disciplines and systems is what constitutes the T-Shaped Professional (see http://tsummit.org/t). ISSIP sponsors a number of conferences, including events that focus specifically on skills, and the collaboration between academia, industry, and government to create more T-Shaped Professionals. Specific events called T-Summits were established and co-sponsored by ISSIP.org to build momentum about existing and potential ISSIP partners on the topic of skills. Furthermore, ISSIP members are encouraged to write short books for the ISSIP Business Expert Press (BEP) collection on a variety of topics related to service systems innovation for business and society.

Therefore, this ISSIP BEP book is designed to both reflect some of the key ideas from earlier T-Summits (See http://tsummit.org, 2014, 2015, 2016) as well as provide a foundation for a T-shaped curriculum and research agenda. It is hoped that T-shaped tracks at two key ISSIP sponsored conference (See AHFE HSSE (summer—http://ahfe-hsse.org) and HICSS (winter—http://hicss.org)) will build on this foundation in the years ahead.

The chapters of this book are written by attendees of the three previous T-Summits (http://tsummit.org). In 2014, the first summit held at IBM Research—Almaden in San Jose, tried to get representatives from most of the major disciplines advocating for the need for T-shapes, as well as industry leaders advocating for hiring T-shaped students and fostering a lifelong learning corporate culture for T-shaped professionals, and governments with programs that encouraged e-skills, entrepreneurship, and future-ready T-shaped adaptive innovators. In 2015, the second summit held at Michigan State University in East Lansing Michigan assembled mostly academic, but also some industry, speakers who could present exemplar pilots and/or success stories of T-shaped transformation underway. In 2016, the third summit held at the National Academy of Sciences building in Washington DC, continued the earlier themes, but also include more government and government funding agencies encouraging the development of T-shaped students and faculty.

Most of the chapters in this book come from academics who have T-shaped transformations underway including curriculum, intended to foster the development of T-shaped students, faculty, university cultures, and of course, lifelong learning T-shaped professionals. However, the chapter by Grainger et al does provide industry perspective, and the chapter by Korte does provide government and policy maker perspective. There are also chapter contributions from organizations aimed at helping university, industry, and governments make needed changes (e.g., Markowitz).

Of course, most of chapters cut across multiple framework areas for a T-shaped curriculum and research framework. Still we have tried to organize the chapters in this book according to the following section structure: ISSIP T-shaped curriculum and research framework outline.[1]

T-shapes would not be needed if (1) if specialization alone is enough to get started, and things change slowly—then the old social-contract still works, and people can use education in the first part of their lives to have one entry level job and one work organization for their whole lives, or (2) if every person could know everything—people do not then need a specialization or area of depth.

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[1] Notice that the ISSIP T-Shaped Professional Curriculum and Research Framework is different from, but somewhat related to the ISSIP Service Science Systems-Disciplines Framework (see http://service-science.info/standards). The systems-disciplines framework is a matrix of 13 types of systems and 13 types of disciplines and summarizes the wide range of conversations for professionals with boundary spanning abilities (and in separate publications, the 13 main cultures are also included). For more figures about the ISSIP - Service Science Systems-Disciplines Framework, see for example, Figure 1 (page 180) in this document: https://www.springer.com/us/book/9781441916273?gclid=CjwKCAjwhLHaBRAGEiwAHCgG3hLzMEtNqMdu5iR8JW6kciurr-QMWW6nDEscsKf8Bb6oUKU3HTWZ8hoCbskQAvD_BwE and here http://pubsonline.informs.org/doi/pdf/10.1287/serv.2.1_2.1; also slide 4 here http://slideshare.net/spohrer/smart-service-systems-20150228-v2

PART II

Education Perspective

CHAPTER 2

An Integrated Transdisciplinary Educational Model and an Associated Faculty Development Model

Carlos Heeren[1], Melanie Cornejo[2], and Julia Lee[3]

Abstract

From its inception, Universidad de Ingenieria y Tecnologia (UTEC) has had the vision of causing a disruptive change in society by educating a new generation of holistic and global Engineers. The University has recently decided on a radical transformation of its curricular model, to be able to truly live up to this vision and deliver its promise to students and society at large. The more flexible and project-centered curriculum will provide its students not only with a strong STEAM (STEM + Art / Design) backbone taught in alternative formats, but also embark them on “real life” Engineering challenges from the onset. The continuous acquisition of professional and soft skills will occur through the seamless integration of these concepts into courses and projects throughout and will ensure the formation of the T-shaped professionals the market and world is in so high demand for.

Keywords

active learning, educational transformation, holistic engineers, professional skills, project-based learning, STEAM

Acknowledgments

We would like to thank, first and foremost, UTEC´s founder, Eduardo Hochschild, for his vision and persistence; UTEC´s Board of Directors, for their support and unconditional trust; our international partners at Purdue´s Polytechnic Institute, Harvard School of Engineering and Applied Sciences (SEAS), MIT, Cleveland Clinic and many other institutions, that believed in and have supported our endeavor from the beginning. We also need to acknowledge our internal change leaders, both on the academic and administrative side of UTEC.

Introduction

Universidad de Ingenieria y Tecnologia (UTEC) was born from the vision of a prominent businessman in Peru, Eduardo Hochschild, who convinced a group of business owners in different local industries, to actively change higher education in the country and the world. Most importantly, UTEC was born as a non-profit organization under the premise of giving any young person access to a world-class and disruptive educational model in Engineering, regardless of his/her socioeconomic status, and only dependent on his proactivity, creativity and intellect.

Last year, and one year before graduating its first class, UTEC´s higher administration and the Board of Directors decided to embark on a radical transformation to ensure the formation of holistic and T-shaped Engineers, true to the University´s vision. This disruptive change is embodied in what is now known as UTEC´s Educational Model (UEM) and relies on two main interrelated pillars that will both be launched by March of 2017:

1. A Fully Integrated Transdisciplinary Curricular Model
2. A Multitrack Faculty Development Model

In short, the UEM seeks to educate holistic professionals, able to understand, disaggregate and solve complex problems in a creative, innovative, ethical way, and communicate these solutions effectively. The model is highly student-centered and aims at empowering and awakening students' intrinsic motivation to learn and come up with new solutions to the world´s most pressing challenges every day. To achieve this, UTEC will provide students with constant real-life experiences in a transdisciplinary setting and close interactions with different industries in Peru and the world. At UTEC, we believe that learning in context and in connection with the real world alongside the most important local and global industries (e.g., mining, fishing, agriculture, environment, chemicals, energy, construction, and health care) is a richer and more effective means for developing our students into life-long, flexible learners and change leaders.

The New Fully Integrated Transdisciplinary Curricular Model

The UEM leverages a novel curricular model as the vehicle or tool to educate and form the T-shaped professional central to UTEC´s promise and vision. This curricular model aims at ensuring that our students attain five main desired learning outcomes, which we deem necessary to become the generation of holistic Engineers necessary for guiding Peru (and Latin America), and ideally the world at large.

1. Deep technical, disciplinary and interdisciplinary knowledge
2. Analytical reasoning and critical thinking for complex problem solving
3. Communication and collaboration skills across cultures and disciplines
4. Ability and will to lead the innovation and change process
5. Ethical and socially responsible thinking and doing on a local and global basis

To accomplish this, the model provides our students with integrated "real-life" experiences that map to a logical and connected framework of courses and projects throughout the five-year undergraduate program (the five mandatory years being in accord with Peruvian legislation). The whole curricular model consists of mutually supporting disciplines, interwoven with interdisciplinary experiences and projects to ensure the development of both technical and professional skills. In addition, this model has been co-developed with and vetted by advisory boards for each career track, consisting of six to eight CEOs of the most prominent (local and in some instances global) companies in related industries each (e.g., in mining, construction, oil and gas, renewable energy, health care, chemicals, software and telecomm, and so on), as well as external advisors from abroad.

All programs at UTEC will start with a core of common math and science (including computer science) courses, whose contents have been carefully revised to match the requirements of more advanced Engineering courses and distilled to the most basic foundational topics. These courses will draw on real-life Engineering applications and will be co-taught by Science and Engineering faculty, with programming and software tools integrated into them. In addition, UTEC´s Introduction to Engineering course, equivalent to those mentioned as crucial components of the CDIO Syllabus (Crawley et al. 2014, p. 102; pp. 110–15), was coined "Global Challenges," as it confronts first-semester students with the UN´s Sustainable Development Goals[4] and guides them to plausible solutions to these challenges through a Design Thinking approach (Brown 2009). Our intent here is to immediately force students from Semester-1 into a mindset of being world citizens, specifically targeting an understanding and realization of their own country's role in contributing to some of the global problems and its ultimate broader impact, while simultaneously guiding self-reflection on one's ability and responsibility to contribute as engineers, and context for learning. The science and math core will be supplemented with social, philosophical, historical, and professional learning throughout

the five years (as discussed subsequently), to continually empower students with the knowledge, tools, and mindset to contribute significantly to engineering solutions for the future of Peru and the world. This course will further develop communication and collaboration skills from the first day, as it is tightly linked and shares learning outcomes with the first of two semester-long Communication Laboratories at UTEC.

Starting their second year, the students have to embark on at least three interdisciplinary projects and implement them successfully at UTEC and beyond, by the end of their third year. These three projects have increasing degrees of difficulty and build up in terms of desired learning outcomes, as well as connection to more traditional course-work. In addition, these projects often connect two or more courses and integrate the development of professional skills in a seamless way, so that our students can embark on their fourth-year internship program having acquired and tested the main skills that the industries or enterprises are looking for (i.e., project management, teamwork skills, leadership, negotiation skills, effective communication, critical thinking and problem-solving, innovation, flexibility and social conscience). Finally, these projects will consist of those posed by faculty (or students in some circumstances), as well as local and global companies that are looking for innovative solutions to some of their most pressing problems. In these cases, the companies work hand-in-hand with one or more faculty members as sponsors and mentors throughout the projects; it also enables them to engage in early scouting for future talent.

In order to ensure the success of these interdisciplinary projects and experiences, we have re-shaped and re-tasked some areas within our campus to facilitate the “design-build-implement-test” process in proper Engineering workspaces (Crawley et al. 2014, p. 131). Accordingly, UTEC has opened a large workspace, called UTEC Garage, where students can gather, exchange ideas, and test them in a safe environment. Likewise, UTEC´s FabLab allows students to

3D-print and prototype any idea very quickly, under the guidance of world-class experts in these fields. More advanced ideas that have been matured over several semesters will have the chance to be incubated in UTEC´s very own business accelerator, UTEC Ventures. The University also holds over 30 laboratories with different field-dependent resources and equipment that are open to students and faculty for research projects or simpler testing/ prototyping of ideas.

During their second and third year, UTEC students are also required to take a series of Business, Humanities, Social Sciences, and Arts courses that feed into their projects and into their professional development. This component ensures the completeness of the STEAM curriculum and the development of holistic professionals. For instance, students register for a three-semester long series of Business and Innovation courses that familiarize them with the most important concepts necessary to start a new business, launch a new product or evaluate a project, using the newest methodologies, such as Business Model Canvas, Lean Startup, Product Archaeology, Agile Software Development, to name a few. All these concepts will be implemented in increasing levels of sophistication during the development of their own projects.

The third-year activities will be particularly important for rounding out professional skills development necessary for ensuring a fruitful internship experience. A semester-long course in Image and Personal Branding, coordinated and organized by UTEC´s Career Services Department in conjunction with our Business, Humanities and Social Sciences Department, exposes students to the tools and resources for a successful job-seeking process and an enriching "real-life experience." Through periodic visits of organizational psychologists, companies´ HR personnel and CEOs of Peru´s most important firms, students get a glimpse of the available professional landscape and what is expected from them as graduating Engineers. Simultaneously, companies can also more closely assess the "incubating talent," their projects and career goals. During UTEC´s

Networking Events, our students will have the chance to pitch to different companies and convince them to hire them to solve their own internal problems and lead the innovation process. This hiring process and closeness to local and global companies is also facilitated by the presence of our track-specific advisory boards, who are working with us and experiencing the development and transformation of our students from their beginnings at UTEC.

The fourth year will be the most flexible year in terms of course load and academic requirements, as to allow students to leave the University to explore the real world through internships, community service, study-abroad or exchange programs, research projects, field work or ventures. These experiences should serve to enrich the horizontal aspect of the T-shaped professional, which has been nurtured and developed throughout the first three years. In an ideal scenario, a student will propose his/her own internship project, based on the interests and skills developed through course-work and projects at UTEC and will deepen on and professionalize this project throughout that fourth year, to then use this as a basis for his thesis work (ideally sponsored and guided by the same company).

The fifth and final year is the culmination of the process and the moment where all the acquired knowledge (vertical and horizontal) comes together for the senior thesis or capstone project. These projects will often be cross-institutional and even international, leveraging our existing and fruitful relationships with important academic institutions across the globe. Students will also be taking their final electives for their minors or specializations, and a Leadership and Negotiation workshop to ensure that our graduating students have reached the highest level of professional skills expected by their future employers. Their final project will be defended in front of a multidisciplinary jury, composed of faculty members, academic directors, our career services department, companies´ highest administration and ideally representatives from our global partnerships.

To ensure coherence and quality of this curricular transformation, as well as a seamless implementation process, the UTEC staff is working closely and consistently with the Harvard School of Engineering and Applied Sciences (SEAS), MIT, the Purdue Polytechnic Institute and the Cleveland Clinic. These three institutions are providing feedback, co-developing some of the novel offerings and methodologies and supporting with the training of the UTEC faculty and change management process.

Faculty Development Model

One of the key success factors for the curricular transformation is the professional development of our faculty toward a project-based educational format and excellence in/passion for teaching and learning. Therefore, UTEC identified the champions and change leaders within the faculty early on in the curricular transformation process and sent them to specific “train-the trainers” workshops and will continue to do so in the coming years. In addition, UTEC has organized two main faculty-wide, week-long on-site teaching and learning workshops to prepare each and every member of the academic department for this disruptive change. The University is also launching a Center for Educational Innovation in February 2017, which will serve as local training center and ongoing support system for UTEC´s faculty throughout the implementation of UEM and beyond. Each faculty member has already been tasked with revising and redesigning his/her course(s), taking into account and introducing the newest tools and methodologies to foster student engagement, motivation, and retention. In addition, UTEC´s higher administration has created multidisciplinary task-forces for the development of the different core courses, so that professors from different departments contribute collaboratively to the re-design of these courses from the beginning, in order to ensure that foundational needs are met for students entering the respective engineering fields.

To support all these changes, UTEC has adapted and is piloting metrics for teaching effectiveness that are currently being developed

as part of a study commissioned by the Royal Academy of Engineering (RAE). These metrics define teaching achievement that are high level and can be broadly recognizable (and therefore portable) between institutions. They are designed with input from 16 Universities globally and one of them is UTEC (Career Framework for University Teaching[5]). The Framework will be used at UTEC to evaluate teaching performance during appointment, promotion, and professional development and aims at stressing the importance and improving the recognition of teaching and learning at UTEC through a standardized and straightforward method for evaluating and evidencing teaching achievement.

This way, faculty members from now on will have to present a performance portfolio, that will include not only their research record (as it has been until now), but also their teaching performance as evaluated from different angles, as well as their service and leadership to the institution at large. These three dimensions will be assessed with equal care, but will be weighted differently for each faculty member, depending on the distribution of work hours agreed upon at the beginning of each evaluation cycle. It will also take into account an individual's passion and aptitude toward teaching versus research, and where said individual can best maximize their contributions to UTEC in these respects. The main goal of the new Faculty Development Model, however, is to stress and have the faculty understand the importance of the teaching and learning process and to implement a student-centered approach to this process. We, at UTEC, view this change in mindset and focus as instrumental for the success of the new UEM.

Conclusions

UTEC has embarked on a major transformation of its education model in 2016, to fulfill its promise of causing a disruptive change in society through the education of a new generation of Engineers. This new model is based on two main, interrelated pillars: a novel curricular structure and a teaching- and learning-focused Faculty

Development Model. We truly believe that the early adoption, enthusiasm, and active participation of the faculty in this transformation have been catalyzed by the fact that the Faculty Development Model was designed and is being launched simultaneously with UEM. It helped faculty understand and make sense of the process and allowed them to grasp the need and the sense of urgency of a shift from a highly research-focused to a more teaching/mentoring-focused institution. One of the main early learnings from our design and implementation process was that the faculty needs to be involved from inception. It is very difficult to expect them to change dramatically and adjust to a model that they have had no say in or do not even fully understand Our supporters had their hesitations about UTEC designing and implementing such a dramatic shift in just over one year (given the history of change at other institutions), but the fact that UTEC is a rather new and comparatively small University with many young energetic faculty is making it manageable. It is obvious to UTEC´s higher administration that there are still numerous pitfalls to be overcome and learning to be made during this and the coming years, but a solid plan of implementation and change management, with clear key performance indicators, will help keep all the involved parties on track and aligned with the overall goal.

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[4] sustainabledevelopment.un.org

[5] http://evaluatingteaching.com/

CHAPTER 3

Bringing T to Community Colleges

Lucia M. Elden[1]

Abstract

Recently, community colleges have become of interest to parents and politicians, in addition to employers. Community colleges are often seen either as a vocational training site, where students begin to develop the "deep" of the T-shape, and a starting place for a college education, where they begin to develop "broad" competencies. In this chapter, I explore two questions that are particularly pertinent to community colleges and those who teach first year students: how early should education begin to cultivate a T-shaped mindset for students, and how can the T-shape facilitate transformational change of education to create graduates and lifelong learners? This can be done through the multidisciplinary collaborative learning that is afforded by general education courses, but introducing the "T" to faculty can also build bridges between vocational and general education faculty for transformation of institutions in the 21st century.

Keywords

community college, lifelong learning, vocational

Acknowledgments

I am grateful for my colleagues at Mid Michigan Community

College for putting up with my "T" promotions. I am most grateful for these student's stories, all of whom happily provided permission for inclusion.

Introduction

After Jeffrey J. Selingo told us his personal story and the history of college in the United States at the T-Summit 2015, he then urged that college needs to become a "platform for lifelong learning," not just a preparation for the first job or the fifth job.[2] In his article "Education for the Jobless Workforce: Are Colleges Preparing Students for the Workforce?" in The Washington Post on June 21, 2016, Selingo questions whether students and higher education focus enough on the job market and its imperatives. For many community college students, however, the mindset that they are in college to be trained for a job—and they often see their first job as their lifelong job—can actually be a formidable obstacle to a mindset of lifelong learning. They often do not believe that developing the "broad" problem-solving and collaborative communication competencies of the T-shaped professional are relevant to this training. Thus, they often regularly de-value their general education courses, not seeing the connection of the general education component of their program as being directly connected to their future work field. In other words, despite the fears of college debt and unemployment after graduation, many students still enter college, but they come with an idea that they are there only to prepare for their first job. They often do not realize that the general education courses are a part of that preparation for that job but also for future jobs—along with important community leadership roles—that they will likely hold as well.

The Role of General Education at Community Colleges

A "narrow-minded" view of college, rather than a "broad and deep" view of the T-shape, is sometimes intensified due the strain and stress of college. In his research on teens after high school,

Clydesdale points out that they often view post-secondary education "instrumentally—as a pathway to a better job and economic security."[3] Of course, this is not to slight this as a goal, but because they often don't understand what the job will entail and that they will likely change jobs, often with greater responsibility and even more broad competencies. Clydesdale continues, "Few teens, moreover, indicate any real interest in intellectual engagement or social broadening, which requires an exploration of cultural factors affecting teen's focus on daily life management during the first year out."[4] This "broadening" and exploration can be done in general education courses since vocational and content area faculty are often focused on specialized training. For example, one of our students, Randy, worked as a manufacturing engineer in five different cities around Michigan due to outsourcing. Through the general education humanities course he took as part of his workforce training, he could understand his story over time and in relation to his father and grandfather. He could understand the short- and long-term effects, understand its relation to a global narrative, and gain collaborative, dialogic literacies.[5]

For students, a focus on the day-to-day struggles and the short term financial benefit of what community college promises them is also often true for returning students who seek retraining. They walk into college with this focus and the time they spend in their technical courses with faculty and other students can strengthen this mindset.

As a result, general education courses are sometimes seen as a roadblock to graduating. Even after providing examples of how they will work with others, they often see themselves as a lone technician, following orders from nursing managers or their automotive repair shop owner. They don't see that they will need to communicate with others with different perspectives or purposes. First year general education courses have the advantage of including students from many discipline areas so that students can learn to communicate on group projects with those with other perspectives. This was the case for Angelo, a student studying heating, ventilation, and air

conditioning (HVAC), but in his general education humanities course had to explain ways in which globalization was affecting his field to students from nursing, accounting, and other fields who did not know anything about his male-dominated field or the ways in which they communicate. In a letter of recommendation for a job for Angelo, I explain some of his "broad" competencies such as cross-disciplinary communication:

He managed the multiple technological projects we had from movie-making to blogging and responding to criticism online. He led the first group presentation and answered challenging questions from the class. He also reflected on how his education in all of the areas helped to develop him as a globalized citizen. Angelo is becoming a strong writer, turning in his midterm essay on a new foreign film experience and narrative essay on male workers in his family earlier than the deadline and with critical acuity. The most significant contribution that Angelo made in the class was his willingness to consider perspectives that the class was not considering…Our class would not have been able to learn as much without his examples and his example of leadership. On the other hand, while he led the first group he was in, he was able to participate in other ways in the second group in which he was a part. He challenged them holistically and worked with other members as they led and organized the project.

After his first presentation, Angelo shouted, "I've been globalized!" He explained that he understood after an opportunity to reflect that his general education courses offered him a larger perspective and had more effective communication. After the semester, Angelo shared his new perspective to other HVAC students and faculty and will soon begin to teach classes himself. Students are used to working with others in their content courses, developing "deep" system discourse and understanding. However, students—and faculty—need to see that learning through multiple perspectives is a contribution that general education courses can make to their vocational programs, especially since many of them will hold

various positions and careers.

Multidisciplinary projects or presentations provide practice to communicate to cross-disciplinary communication. Addressing medical education, Donofrio, Spohrer, and Zadeh explain the connection between cross disciplinary learning in a college education and potential career changes:

Educating more T-shaped people can improve the performance for multidisciplinary teams (which apply discipline knowledge) and interdisciplinary teams (which apply and create new knowledge), but it also sets the stage for true transdisciplinary thinking for the first time. Transdisciplinary thinking is perhaps as large a change (and investment) as when some countries decided that it was time for all citizens to have the right to a public education. Specialization has efficiency advantages (one person, one career), but for the society as a whole, a population with a general education is better prepared to adapt to change, and is given greater freedom of choice in careers.[6]

Students often have a "one career" perspective instead of a "platform" image of their education. After listening to the Computer Assisted Drafting (CAD) and automotive group presentations, Jeni, a mom and returning student in business information systems who works at a car dealership, claimed that their career path seemed immensely more interesting to her. Even career development and academic advisors don't always realize how many "career" conversations that faculty have in general education courses—both in offering broad perspectives but also in learning about future careers.

The T-shaped metaphor, as Selingo argues in The Washington Post article from June 1, 2016 called "The Myth of the Well-rounded Students? It's Better to be 'T-shaped'" that the "T" is a better metaphor than the goal of creating "well-rounded" persons. He explains that because persistence is necessary for a "growth mindset" the metaphor of becoming "well-rounded" is less useful because it supports the notion of individual achievement in a highly

competitive system. Thus, if group work fails, people simply blame others rather than learning new problem solving and communication inquiry. The T-shape supports an ethical approach to education. Biesta posits that all three functions of education are necessary for an ethical perspective: qualification, or the deep ability toward mastery in a disciplinary area that is required by the field; socialization, or ways to communicate needed by a particular community; and subjectification, or learning about one's unique self.[7] This final function includes ways they might embody other roles. Angelo joined a group of single mothers on our final project in the humanities class. They decided to study how to parent in order to help prepare children for a global world. He often discussed the challenges he had with his young daughters and decisions about technology. Complicating the idea of a simple job training perspective is an important aspect of college if we hope for lifelong learners. In order for students to be more open to this possibility, it is important to introduce this perspective early in a college education, particularly at the community college level, considering that nearly half of all college students are at the community college.[8]

An explanation of the T-shape can help students to see the connection between the "broad" that general education courses offer and the "deep" that the vocational part of their program develop. Having this conversation in the first semester of a student's college career is essential for the possibility of openness to developing both the broad and the deep of T-shaped professionals, as they also consider the transition they are making in college. While this can happen in a freshmen seminar or in a first year composition or math course, it can also occur in a content area. For example, Elizabeth Hane, forest ecologist, presented at the T-Summit 2016 on how Rochester Institute of Technology introduces "broad" ethical perspectives in a general education university requirement.[9] In her presentation "Supporting underrepresented students in STEM disciplines through metacognitive practices," she explained how starting a guided reflection practice can help students move to a "growth mindset."[10] Another example is my colleague Ryan

Dziedzic who teaches biology invites students who are mostly going into health professions to create a "public service announcement" in which each 2 to 3 person team chooses a disease related to either the integumentary, skeletal, muscular, or nervous systems and create a poster, video commercial, or skit to share that information with the general public.

General education faculty can help students in understanding learning problems that they encounter. For example, a student named Liam worked as a motorcycle mechanic. At only 18, he decided to start college in Computer Assisted Drafting (CAD). When I asked him what his biggest learning challenge in college was he explained that many of his CAD classmates had work experience in the area, and because he did not, he was having difficulty with the material. This became his inquiry for our composition course where he explored multiple ways to learning this new discourse, in becoming a part of this new "team." I explained my work with Liam to the CAD faculty, who along with the other vocational areas are required to have public program reviews, even suggesting with humor that I am a CAD instructor, a nursing instructor, and an automotive instructor.

Assessment and the T-shape

The T-shape can be connected to the assessment process of the program. For example, at Mid Michigan Community College (MMCC) we have a college-wide assessment program using the Degree Qualification Profile (DQP). The T-shape has helped students and faculty to understand the connections, the border crossing competencies, or proficiencies as they are called in the DQP. Students should be made aware of the assessment process of the college, and in connecting it with the T-shape, students can have a visual to take with them as they move through their program all the way to their graduation or their transfer to a university.

In the past year the study of the T-shape has shaped MMCC in significant "border crossing" ways. We have had interdisciplinary

discussions on teaching and the "T" in biweekly afternoons called "Time for T." Out of this multidisciplinary professional development discussion, two faculty—from English and a biology—began to meet and create a learning community between two courses, initiating some preliminary research. Another presentation between an English faculty member and a business faculty member presented at Trends in Occupational Studies conference in Detroit in 2016. In addition, a Spring Student Showcase was established where deep competencies were displayed from welding students presented guitars they welded, an automotive student showed off the engine he built to nursing and plastics engineering students showed their design and presentation skills on videos they created on globalization in their humanities course. A student brought the guitar to a job interview as a demonstration of his skill, but for all of the student presenters, they had opportunities to answer questions and talk with faculty, students, and administrators about their project. It is clear that after decades of entrenched resistance between vocational/content area faculty and general education faculty, the "wall" is disintegrating, and the "cold war" is coming to an end. Learning how to help students become T-shaped learners can revitalize the work of the community college faculty and help us continue to develop our broad border crossing competencies as T-shaped professionals.

Conclusion

To be generative and transformative, the T-shape needs to be introduced to faculty and students early and often so that students can have a way to frame all the parts of their education, to build bridges among faculty teams, for potential professional development of faculty, and for the educational institution itself to make its full impact for the future. In my experience having a faculty-driven approach with support from higher level administrators is more effective than a top-down approach. In any case, more empirical research is needed, particularly narrative inquiry's framework of "inward, outward, backward, forward, and situated within place"[11] in order to get a full range of perspectives. For me, I am looking

forward to having more conversations across disciplines. I also am looking forward to becoming Angelo's colleague.

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[3] Clydesdale (2007).

[4] Ibid.

[5] Alford and Elden (2013, pp. 84–85).

[6] Donofrio, Spohrer, and Zadeh (2017).

[7] Biesta (2008).

[8] American Association of Community Colleges (2017).

[9] Hane and T-Summit (2016).

[10] Dweck (2006).

[11] Clandinin and Connelly (2000).

CHAPTER 4

Force Field Analysis: A Way to Look at Challenges Facing Universities as They Try to Produce T-Shaped Graduates

Jana Markowitz[1]

Abstract

Several universities have determined that employers of 21st century workers are demanding a different "product" from them. Instead of a graduate with deep disciplinary knowledge in one major academic area (known as I-shaped), employers want someone with both the disciplinary knowledge and broader knowledge—in project management, collaboration, critical thinking, "soft skills," and a smattering of other disciplines and systems (known as T-shaped). To create these desired T-shaped graduates, universities are committing, whether they realize it or not, to massive change. To produce a different graduate a university must change curriculum, student counseling, faculty and staff mindsets, career services, and more. Producing and then getting T-shaped graduates employed requires such massive, complex changes—both in the university environment and externally—that it is important to develop a big-picture view of the major forces working for and against the change. Force field analysis is one approach to developing perspective on the challenge.

Keywords

21st century worker, career services, cross-disciplinary, force field - analysis, soft skills, T-shaped

Acknowledgments

Thank you to Steve Alter for making me aware of the T-shaped concept and to Jim Spohrer for giving me a reading list and then inviting me to the T-Summit. I finally have a way to describe what I am trying to help clients achieve in developing their staff and leaders: T-shaped.

Evidence Employers and the World Need a T-Shaped Work Force

Some universities have determined that employers of 21st century workers are demanding a different "product" than the graduates they are producing today. The Collegiate Employment Research Institute's CERI Research Brief 5-2013 says,

…the new normal requires colleges and universities to demonstrate the value proposition of the various degrees they offer or face the consequences of declining enrollment throughout the institution or within those disciplines that fail to meet some prescribed test of accountability…not all organizations…will embrace a liberal arts candidate for a position. (Chan and Gardner 2013)

Instead of a graduate with deep disciplinary knowledge in his/her major academic area (known as I-shaped), which U.S. colleges and universities routinely turn out, employers want someone with both the disciplinary knowledge AND broader knowledge—in project management, collaboration, critical thinking, "soft skills," and a smattering of other disciplines and systems (known as T-shaped). Employers want an entry-level employee who can hit the ground running—who understands that workplace relationships are important, that collaboration and negotiation skills are critical and that communications—oral, written and digital—are crucial. They want people who are using both the analytical (technical skills) and

design (soft skills) sides of their brains as Daniel Pink explains in his book, A Whole New Mind.

The last few decades have belonged to a certain kind of person with a certain kind of mind—computer programmers who could crank code, lawyers who could craft contracts, MBA's who could crunch numbers. But the keys to the kingdom are changing hands. The future belongs to a very different kind of person with a very different kind of mind—creators and empathizers, pattern recognizers, and meaning makers. These people—artists, inventors, designers, storytellers, caregivers, consolers, big picture thinkers—will now reap society's richest rewards and share its greatest joys.

We are moving from an economy and society built on the logical, linear, computer-like capabilities of the Information Age to an economy and a society built on the inventive, empathic, big-picture capabilities of what's rising in its place, the Conceptual Age. (Pink 2005, pp. 1–2)

According to the National Association of Colleges and Employer's (NACE) survey, "Job Outlook 2016," over 70 percent of employers indicated they look for the ability to work in a team, communication skills, and problem-solving skills in new college graduates. Of those respondents 59 percent also cited technical skills as desirable (NACE 2016).

Beyond team work, soft skills, and technical skills, employers are also looking for the ability to innovate. Michael Schrage makes the argument in his Harvard Business Review article that innovation is now everyone's job.

"Being diligent, dedicated and super-competent used to be enough to get the job or win the promotion. These companies now want prospective hires and promotion candidates to show they are ready, willing, and able to collaboratively create new value. Innovation attitudes, not just aptitudes, matter." (Schrage 2016)

According to Trish Cotter, Associate Director of the Martin Trust Center for MIT Entrepreneurship, and Lecturer, MIT Sloan School of Management, increased globalization is creating a need to lead across cultures. Additionally, a broader level of knowledge, which she describes as boundary-spanning, is more critical than ever. She also quotes GE CEO Jeffrey Immelt, who says management capabilities for this century will require an "ability to handle ambiguity" (Cotter 2014).

The T-shaped candidate meets employer's innovation requirements as well as the boundary-spanning capability. According to IBM's Dr. James Spohrer, "T-shaped individuals can adapt and change faster than people who lack boundary-spanning abilities, customer empathy, and the greater knowledge of self that are all hallmarks of being a future-ready T-shaped adaptive innovator" (Spohrer 2016).

Vanderbilt University's Executive Director of the Evans Family Career Center, Katharine Brooks, Ed.D., says in her Psychology Today article, "Career Success Starts with a 'T'":

…the most sought-after candidates for management, consulting, research, and other leadership positions are T-shaped. The vertical stem of the T is the foundation: an in-depth specialized knowledge in one or two fields. The horizontal crossbar refers to the complementary skills of communication (including negotiation), creativity, the ability to apply knowledge across disciplines, empathy (including the ability to see from other perspectives), and an understanding of fields outside your area of expertise.

Organizations need workers with specialized knowledge who can also think broadly about a variety of areas, and apply their knowledge to new settings. Since T-shaped professionals possess skills and knowledge that are both broad and deep, developing and promoting your T-shaped talent may be the ticket to your career success now and in the future. (Brooks 2012)

The International Youth Foundation (IYF) performed in-depth

qualitative interviews with executives from Accenture, Hilton, Walmart, Ernst and Young, Blackboard, and a number of South Africa's major retailers to determine the soft skills requirements for entry-level service sector jobs. They additionally reviewed 45 secondary sources including publications from human resources and development professional organizations as well as business and education academic journals. In seeking a broadly accepted definition for soft skills, IYF found contrasting soft and hard skills provided the clearest definition: "Hard skills are technical competencies and domain knowledge while soft skills are a combination of people skills, interpersonal skills, communication skills and emotional intelligence" (Rao 2012).

One of the IYF's key findings was that competencies for entry level service sector employees in customer service positions include the following soft skills:

- Customer service
- Communication
- Team work and interpersonal skills
- Organizational and planning skills
- Critical thinking and problem-solving
- Creativity
- Culture sensitization
- Presentation and professionalism
- Work ethics—integrity and reliability
- Self-assessment
- Ability to receive constructive feedback

Their interviews also surfaced a widespread concern over the lack of soft skills in new hires. Unfortunately they found that corporate training focused on technical skills and training manager-level staff,

leaving their new hires with persisting poor soft skills. Their most relevant finding for colleges and universities was, "The literature indicates that soft skills training is typically scattered, insufficient or quasi nonexistent in higher education programs across the globe" (IYF 2013).

What Higher Education Must Do to Create T-shaped Graduates

In order to create these desirable T-shaped graduates, colleges and universities must commit, whether they realize it or not, to massive change. To produce a different graduate they must change not only curriculum and majors, but also student counseling, faculty and staff mindsets, career services, and more.

To make curriculum and majors cross-disciplinary a university must foster collaborations between faculty members, departments, and colleges which have, for the lifetime of the university, (and in all likelihood for individual faculty member's entire careers) been adversarial, competing for internal funding, research grants, and students. Old habits and behaviors of faculty and staff may be extremely hard to change. In general faculty seek to create graduates in their own image—but the majority of faculty today are not multidisciplinary, so how willing (or able) will they be to create multidisciplinary graduates? How capable will faculty be in guiding students in what majors, minors, or double majors to pursue?

If you are the Dean of a school, how open will you be to allowing students majoring in your school to spend a large portion of their time taking classes in a different school? Should engineers be taking lots of liberal arts classes? If so, how do they fit them in with few or no electives permitted in their very tightly filled required curriculum? Should an English major take Engineering classes? Or computer fundamentals and programming classes? Would an English Department professor be able to advise that English major capably in what technology classes to take? Will the schools let students from

other schools take their courses—or will they always prioritize their own majors and effectively block students from other schools from taking needed multidisciplinary courses?

These questions lead to the new role Career Services might play. Should they, instead of faculty, be advising students on majors, minors, and specific skills to seek? Should Career Services no longer be only the organization that points students to internships sophomore and junior years, then in senior year to permanent jobs? It appears they should have a four-year role helping students understand what the world will offer as jobs/careers when they graduate as well as trying to find the many areas that interest the student. They need to help students understand what they want to do after graduation, but also over a lifetime.

While the Bureau of Labor Statistics (BLS) does not track "number of career changes" in a lifetime—primarily because it is extremely difficult to define career change—they do track number of jobs. A BLS news release published in March 2015 examined the number of jobs that people born in the years 1957 to 1964 held from age 18 to age 48; these younger baby boomers held an average of 11.7 jobs from ages 18 to 48. (In this report, a job is defined as an uninterrupted period of work with a particular employer.) On average, men held 11.8 jobs and women held 11.5 jobs (BLS 2015).

Future Workplace, an HR executive network and research firm, reports that the organization's 2012 Multiple Generations@Work survey revealed 91 percent of respondents born between 1977 and 1997 (often referred to as Millennials) expect to change jobs every three years. HR professionals conservatively estimate this means changing careers four to seven times over a 40+ year work life (White 2013).

This means higher education Career Services organizations need to prepare students for four to seven careers, not one. A student's course work should include broad areas that will qualify them to return to school for additional degrees, or enable them to pursue

training for specific certificates in fields other than their primary undergraduate field.

How Should Higher Education Approach These Changes?

The changes needed in the higher education institutions trying to produce T-shaped graduates, which we outlined previously, are certainly nontrivial. Making changes, even small changes, is very difficult for most people. Rosabeth Moss Kanter in one of her Harvard Business Review articles cites 10 reasons people resist change, including the following:

- Loss of Face
- Loss of Control
- Uncertainty (no clear path; no sense of safety)
- Surprise (decisions imposed suddenly)
- Concerns about Competency (their own competency; fear of not being able to learn the new way) (Kanter 2012)

Faculty and staff in secure, senior (tenured) positions might experience all of these feelings that inspire resistance to change. Human beings have very narrow comfort zones and do not like to be pulled out of them. Knowing this about people makes the effort of transforming, or completely reinventing, higher education to produce a graduate with different skills, competencies, and characteristics than the traditional college graduate seem quite daunting. As an organizational change consultant, the author would approach implementing these changes by first analyzing the forces acting for, and against, the change. This approach to change management was first popularized by organizational psychologist Kurt Lewin in 1951 (Lewin 1951). He called the approach force field analysis.

Figure 4.1 shows a force field analysis diagram with “Universities to

begin intentionally producing T-shaped vs I-shaped graduates" as the proposed change, which includes the many changes identified previously. The left of the diagram shows forces pushing for the change. The right of the diagram lists forces pushing against the change.

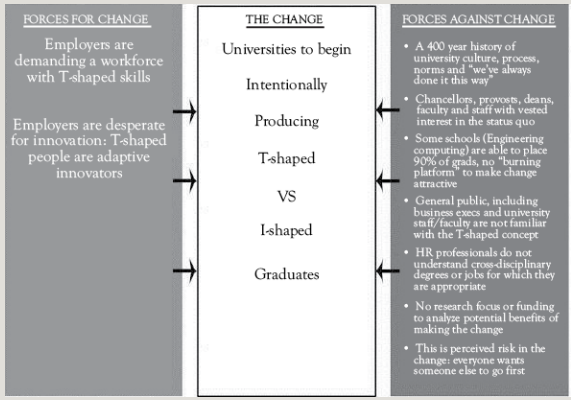

Figure 4.1 Force field analysis for T vs. I shape professional

Lewin, after using force field analysis in his own work, suggested that strengthening the forces "for" a change was not as effective in bringing about the change as removing or lessening the forces "against" the change.

While the author has listed both forces for and against the change, groups of academics who are engaged in trying to make this change happen at their institution could no doubt provide more forces on both sides of the equation. The key to this analysis is not so much that the forces listed must be an exhaustive list, but that the analysis should lead to a list of actions to lessen the forces against the change.

In the case of the list described previously it seems apparent that one immediate action which would help reduce the "against" forces is educating people—business executives, faculty and staff at higher education institutions, and HR professionals and recruiters—on the concept of T-shaped people and why they are desirable employees

for the future workforce. The T-Summit has gathered people from higher education, corporations, nonprofits and government agencies to do precisely this type of education. However, the reach of the conference has only been a few hundred people each year; future efforts should likely include more mass media, social media, and online videos in order to create a ripple effect from conference attendees outward. This book may produce that sort of spreading effect.

Conclusion

Getting a good perspective on how to approach this watershed change—that is, changing the skills, competencies, and mindset of the graduate produced by higher education—is an important first step. Once a number of institutions collaborate in creating force field analysis diagrams of their efforts, they can find commonalities across institutions. They might also share what works and does not work in addressing the restraining forces. Even though people presumably are aware of most of the forces working against their efforts to produce T-shaped graduates, the author has found in most of her consulting engagements that creating a visual representation of the forces, a force field analysis chart, clarifies and justifies the actions that must come. The author has no silver bullets or formulaic methodologies to make this change easy; however, it is impossible to loose restraining forces if one has not identified them and formed a coherent strategy. The author looks forward to future conferences, discussions and collaborations which can carry this analysis deeper. With enough contributions it might be possible to develop a framework for implementing this specific change which each institution could customize for its own situation and needs.

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CHAPTER 5

Rating and Ranking Universities, What Criteria Is Most Aligned with Creating T-Shaped Faculty and Students?

Gary S. Metcalf,[1] and Stuart A. Umpleby[2]

Abstract

For many years people in government and business organizations have urged universities to try to produce T-shaped people who have both technical expertise and an ability to work well with others. In recent years universities have moved strongly in the opposite direction, toward greater specialization. This article will describe why this change has occurred and the effect on universities and on the creation of T-shaped people. We end with two suggestions: One way to broaden the thinking of students is to increase the attention paid to multidisciplinary fields such as systems science. A second possibility is for business and government to expand internal programs, such as corporate university curricula, to include those aspects of a T-shaped body of knowledge that universities are not covering.

Keywords

corporate universities, cybernetics, process improvement methods, systems science

Introduction

Large organizations in business are staffed by people who need technical expertise and an ability to work effectively with other people. Universities, on the other hand, are staffed by people with detailed knowledge in a single field and only limited knowledge in other fields. Faculty members win promotion by becoming experts in usually quite narrow fields. Consequently, they need to be reminded of the need that students have for broad understanding and interpersonal relations skills. This need is usually fulfilled in universities by administrators who repeatedly emphasize the importance of interdisciplinary communication and cooperation. Statements by people from business and government organizations, expressing their desires for graduates with T-shaped skills, reinforce these needs for faculty and students. However, in recent years the emphasis in faculty hiring and promotion has been in the opposite direction toward greater specialization rather than balance between breadth and depth.

Why There Has Been an Emphasis on Specialization

There is a self-reinforcing cycle of factors which works against the breadth of learning needed for T-shaped professionals. This cycle involves specialized knowledge which supports the division of labor; research as reinforced by funding sources; academic journals by which faculty are judged with respect to publications of their research findings; and curricula which are based on research, and on the topics in which faculty specialize.

Further, what organizations measure and reward significantly affects their end results. The importance of T-shaped people has been recognized for some time (Hansen and Oetinger 2001). The primary emphasis in U.S. educational systems, however, has been toward STEM (science, technology, engineering, and math) programs. Compounding this movement has been the significant rise in student loan debt and concerns about degrees leading to employment, which

would allow for repayment of those loans. The value of breadth is well-recognized, but what seems to matter in the marketplace are specialized, technical skills.

An added complication has been the advent of consumer rating systems, which now apply to universities. Prospective students (and for many undergraduates, their parents) can see universities assessed and ranked online without having to visit or research for themselves. In response, universities play to the ranking systems, which thus far seem to have little, if anything, to do with producing T-shaped professionals. This has affected not just US universities but most well-known universities around the world, as they compete for a single pool of potential students. Each of these topics will be expanded and explored in this paper.

Breadth and Specialization

There has long been a difference between what business and government say is needed (T-shaped people) and what academics like, or feel pressured, to do (e.g., advance their disciplines). For many years, a broad curriculum in the first two years of undergraduate studies and a more specialized curriculum in the second two years was the consensus strategy. For reasons noted previously, there has been growing pressure to reduce the time and expense needed in education. This has tended to privilege technical and quantitative skills over ones such as literature, critical thinking, or communication.

The cycle described previously might make sense if only narrow specialization were needed in practice by organizations. That is obviously not the case. Moreover, research reveals that practical problem-solving ability and breakthrough research are produced by multidisciplinary teams (Hollingsworth and Hollingsworth 2000; Hollingsworth, Hollingsworth, and Hage 2006).

The Challenge for Universities

Faculty are hired and promoted in research-oriented universities, based on their contributions to bodies of knowledge, as evidenced through their publications in academic journals. This process is familiar and well understood in most countries. Increases in knowledge have supported innovations and societal advances of many kinds. An ongoing challenge, however, has been bringing knowledge together across domains, as well as the coordination of work involving many specialists. The more complex problems become, the less adequate is a single domain of knowledge for solving them. Likewise, the more complex our innovations, the more interconnected are the relevant domains of knowledge involved.

Many organizations now see the need for T-shaped professionals, those with deep expertise and a breadth of capacity in understanding and applying knowledge across domains. A looming question is how to foster such professionals, especially through the traditional university system.

Historically, universities were known by their reputations, associated with prestigious faculty members and alumni (e.g., Nobel laureates), important institutions (e.g., members of Congress), research breakthroughs, and so on. Presently, students and their parents select universities based largely on the annual rankings of universities published by sources such as U.S. News and World Report and The Financial Times. These rankings are important because they influence how many students apply to a university. The number and quality of applicants has a large impact on a university's revenue and the quality of the academic climate. Consequently, universities around the world are devoting great energy to improving their performance on the factors that are used in the rankings. The efforts by universities to improve their rankings are certainly admirable. But are the factors used in the rankings the best indicators of quality universities, and does this redirection of faculty attention improve the quality and production of research or improve the educational experience for students?

Studies of research productivity raise doubts (Umpleby, Anbari, and Mueller 2007; Shneiderman 2016). For years, studies of high quality research organizations have found that breakthrough research—research that redefines a field—almost always is produced by multidisciplinary teams. Consequently, by changing the evaluation of faculty research from high-impact contributions in specific fields of study to simple counts of articles in highly ranked journals may be misdirecting faculty efforts.

To rise in rankings, many universities have altered their policies, particularly the way they evaluate faculty research. The current rating scheme rewards universities whose faculty members publish in the top journals in their field. The "tyranny" of the top journals was criticized by Nobel laureate Randy Schekman in 2013, when he called for a boycott of Nature, Science, and Cell, arguing that they actually distorted the progress of science (https://theguardian.com/science/2013/dec/09/nobel-winner-boycott-science-journals).

Sometimes publications in interdisciplinary journals are not counted at all. In the past, faculty members were expected to publish in journals with a high impact factor, but there was less emphasis on journals in the faculty member's field or those geared toward practitioners. [I think this last phrase is not what we want to say.] The result is that now doctoral students and young faculty members will often immediately reject an opportunity to work on an interdisciplinary research project on the grounds that such work will not help them find a job or be promoted. In fact, such work will require time and effort that could be used on projects that will aid their careers.

Public Ranking of Universities

How did it happen that business publications came to be in the position of deciding how universities are evaluated? At a macro level, there are at least two answers. First, large bureaucracies, including universities, became the icons of inefficiency. Critics of

bureaucracies most commonly offered market-driven competition as the answer to improve efficiency, regardless of the nature of the institution. Banks, insurance firms, health care networks, and schools were all pushed to become more market-driven and competitive. The second answer has to do with the speed and proliferation of data and scholarship. In a world where data overload has become the norm, rankings have become the filter for finding only the "best" of any given category, saving curious searchers from wasting time exploring inferior choices. Appearing at the top of a list of search results has become an imperative unto itself.

From the perspective of universities, a high ranking appears to correlate with large endowments. For 2014, seven of the 10 U.S. universities with the largest endowments also fell into the top ten ranking of the U.S. News and World Report list (http://usnews.com/education/best-colleges/the-short-list-college/articles/2015/10/06/10-universities-with-the-largest-endowments). That does not equate with cause and effect, but it is easy to see why college presidents and boards would aspire to the prestige of top rankings. From the perspectives of parents and students, getting into a highly ranked university is believed to correlate with post-graduate success, due to the personal connections made with influential people, or the apparent prestige of the degree, or both. Given the rising costs of higher education, and of student debt in the United States, it is no surprise that students and their families would want to maximize the return on their investments. Unfortunately, there are no guarantees.

According to a Bureau of Labor Statistics report (https://bls.gov/cps/minwage2012tbls.htm#6), the rate of college graduates working minimum wage jobs increased by 71 percent between 2002 and 2012. A college degree has become a necessity largely because of the poor prospects for employment without one (e.g., only having a high school diploma).

One recent analysis argues that we should return to a higher level of public funding for education. The rationale is two-fold. First, funding

has dropped to the point that 62 percent of the costs for higher education in the United States come from private sources. That compares with the OECD average of 30 percent (https://www.oecd.org/education/CN%20-%20United%20States.pdf).
Second is the argument that higher education produces significant public good, in addition to the private good of better jobs and income.

The intent to measure quality in higher education is certainly admirable. The related questions are what should be measured, and why, and how? The U.S. News and World Report ranking system includes seven criteria, weighted in the following ways:

- Undergraduate academic reputation (22.5 percent)—based on surveys of college administrators and high school counselors
- Retention (22.5 percent)—six-year graduation rate plus first-year retention
- Faculty resources (20 percent)—class sizes, faculty salaries, and so on.
- Student selectivity (12.5 percent)—admissions test scores and class ranking of entering students, plus acceptance rates
- Financial resources (10 percent)—average spending per student on instruction, research, student services, and so on.
- Graduation rate performance (7.5 percent)—difference between a school's six-year graduation rate and the rate predicted by U.S. News and World Report
- Alumni giving rate (5 percent)—average percentage of living alumni with bachelor's degrees who gave to their school

Unfortunately, nothing about these criteria reflect a move toward the

creation of T-shaped professionals. If anything, they have moved away from traditional notions of quality in higher education. They reflect something closer to consumer satisfaction with a service rather than the measurement of learning in the context of what is needed in the society at-large.

Redesigning Universities to Produce T-Shaped People

If a new rating scheme is developed to guide a more relevant education, other improvements could be considered as well. The current rating systems interfere with research productivity by emphasizing journals with very high rejection rates. What about the kind of research and teaching that is done? Universities tend to be overly specialized, both in research and in teaching. But problems in the world do not appear like problems at the end of chapters in textbooks. The ability to encounter a real world problem and formulate and enact an appropriate response, usually working with a group of people, requires skills that go beyond textbooks used in courses. Those skills are highly prized by employers in business and government.

Systems scientist John Warfield (1996) suggested a structure for a university that would educate some people with these skills. His design was proposed as a solution to an earlier problem. In the 1950s, 60s, and 70s several systems science centers and institutes were established on university campuses. These centers brought together faculty members from several disciplines—for example, mathematics, philosophy, engineering, social science, management, and medicine—to work on pressing social problems. In the 1980s and 90s, most of these programs closed. The engine of destruction was the accrediting organizations. Periodically academic programs are accredited by organizations that examine indicators of program quality, for example percentage of PhD qualified faculty, faculty to student ratio, and so on. Accrediting organizations usually insist that all programs in a field on campus be evaluated. For example, the MBA accrediting organization does not want there to be business or

management programs on campus that they have not evaluated. This usually meant that a management program in a systems science center would have to be closed or moved into the accredited program in the Business School. Over several years each accrediting organization would visit a campus and carve out a part of the systems science center. When there was little left, the center would close.

To protect multidisciplinary programs Warfield proposed a different structure for a university. The schools of a university would be grouped into three colleges. A Heritage College would teach what has been learned in the past—the sciences, arts and humanities. A Professional College would focus on present activities—Schools of Business, Law, Medicine, and Engineering. A Horizons College would focus on future challenges. The curriculum would be interdisciplinary and design oriented. Faculty and students would work with clients on real problems. Faculty members from the other two colleges would work on problems when their skills were needed. Hence, the Horizons College would serve as a catalyst for cross-disciplinary communication within the university. The core curriculum of the Horizons College would be systems science and cybernetics, highly interdisciplinary fields which tend not to find a home in existing universities. The purpose of this structure of the university would be to protect the design oriented, problem focused activities in the Horizons College from discipline-oriented accrediting organizations and create a home for systems science and cybernetics curricula. A different accrediting organization could be created for such programs.

Conclusion

It seems that people in business and government want universities to educate T-shaped people, but people in universities, while probably in agreement, have other opposing goals and priorities. What is to be done? One course of action is for advocates of T-shaped curricula to work with what seems to be a growing educational reform

movement. Rather than begin with basic science, programs could start with practical, service-oriented courses. Encouraging design schools and structures similar to Warfield's Horizons College would probably achieve much of the T-shaped agenda. A supportive action would be to offer courses in systems science and cybernetics since these fields provide both breadth and depth. They aid cross-disciplinary communication, and they emphasize participatory methods as the way to work with social systems.

A second course of action would be for businesses and government agencies to incorporate into their own training programs the T-shaped educational material that is needed but that universities are not providing. Something similar happened in the 1980s when there was great interest in quality improvement methods in businesses, governments, and universities, following the success of quality improvement programs in Japan. When it became clear that universities would not modify their curricula as far as businesses wanted, corporations adopted quality improvement methods as the core curriculum in their in-house training programs (Umpleby 2002, 2015). Corporations decided to provide the remedial instruction needed for graduates of university programs.

Before we begin to measure, we need to determine what we actually value, and why. Bela H. Banathy spent 20 years at the Far West Laboratory for Educational Research and Development. His contention was that our educational systems were vestiges of the Industrial Revolution, and could not simply be reformed. They needed to be designed anew fundamentally, in relation to the environments which they served. The approach he suggested was large-scale social systems design, involving all relevant stakeholders (Banathy 1991, 1996).

Similar calls for fundamental change have been echoed at T-Summit meetings over the past three years (http://tsummit.org/). Using different words, the same sentiment was expressed in a recent Harvard Business Review article by Joseph Aoun, President of

Northwestern University (https://hbr.org/2016/04/hybrid-jobs-call-for-hybrid-education). He calls for a hybrid educational model to meet emerging hybrid job demands.

If we take seriously the need for T-shaped professionals, changes in our educational systems are essential, and incremental change will not be enough. Better measurement of the status quo is the wrong direction. What we need is a measurement of "fit" with the new societal structure that is taking shape. A decade from now, we may be comparing the changes in education (more likely, in processes of learning) with the changes from railroads to aircraft, or from adding machines to computers.

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CHAPTER 6

“T” Is for Transdisciplinary

Jeffrey J. Evans[1] and Aubrey J. (AJ) Hocker[2]

Abstract

The Purdue Polytechnic Institute has embarked on a mission of transforming itself to embrace and prepare the T-shaped technical professional needed to impact and thrive in the 21st century, global, digital, thinking economy. To help inform undergraduate curriculum transformation, a group of faculties spanning disciplines from the humanities to technology studies was formed to “incubate” new forms of learning and assessment. This chapter describes our transformational approach to creating T-shaped professionals. The incubation period has resulted in a regionally accredited competency-based program, one of the first in the nation at a research intensive university. In order to maintain programmatic and pedagogical agility we have evolved learning experiences from separate studio and seminar experiences to a combined experience that encourages creativity from students and faculty.

Keywords

competency-based education, transdisciplinary, T-shaped

Acknowledgments

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Introduction

The Purdue Polytechnic Institute (formerly called the College of Technology) has embarked on a mission of transforming itself to embrace and prepare the T-shaped technical professional needed to impact and thrive in the 21st century, global, digital, thinking economy. Several key elements including learning in context, integrated humanities, team project-based learning, and competency credentialing combine with real-world learning by way of capstone projects, internships, and global/cultural immersions encourage practice not just in the stem of the "T," but across the top of the "T" as well. This paper explores the first major result of the transformation, a unique Bachelor's degree program that combines individualized learning, faculty mentoring, and competency-based credentialing that emphasizes the top of the "T" for the T-shaped technical professional. The following section provides background and motivation for the program, followed by perspectives from faculty and students. Future directions will then be examined.

Background

To help inform undergraduate curriculum transformation, a group of faculty spanning disciplines from the humanities to technology studies was formed to "incubate" new forms of learning. Beginning in the fall of 2013, these faculty brainstormed seemingly radical concepts like "individualized learning," "learning in context," "mentor/protege relationships," "liberal arts integration," and "competency" to show what you can do with what you know. Investigative "road trips" to Olin College, the d-school at Stanford, Ideo, Apple, Electronic Arts, and Cal Poly San Luis Obispo helped inform early conversations and prepare the group for the challenges ahead. The group also performed research to better understand the needs of the 21st century workforce and society in general, which included work done by the Association of American Colleges and Universities (AAC&U) (Hart Research Associates 2013) and the group that formed the idea of the "T-shaped" professional (Gardner and Spohrer 2017).

Over the course of a year a philosophy was developed centered around three core values: (1) Students are partners in learning and teaching, (2) Faculty are partners in learning and teaching, and (3) Questioning, Experimenting, Learning, and Sharing are at the center of everything we do. The mode of operation would be focused on (1) Continuous research and experimentation; (2) Strong assessment, rapid learning (both students and faculty), and rapid iteration; and (3) Shared ownership and shared accountability. The group determined primary deliverables as:

- Research alternative approaches to the development, delivery, and governance of learning
- Development and implementation of learning experiences
- Dissemination and sharing of everything we learn
- Advocacy and fundraising through grant writing and applications to federal agencies and foundations

The strategy for developing learning spaces and environments, pedagogies, curricular themes, and assessment mechanisms, focused on promoting the ideals of (1) The student taking ownership of their learning by developing flexibility in their program of study, (2) Intentional and continuous faculty mentoring of students, and (3) Students demonstrating their learning by showing what they could do with what they know. The values, ideals, and deliverables were our primary focus while preparing for a fall 2014 first cohort of students. During the spring and summer of 2014 we were consulted by those who we grew to know during our investigation phase and had participated in transformative change in education. We are particularly grateful to Dave Goldberg of Threejoy Associates, and Mark Sommerville, Rob Martello, and Jonathan Stolk, all from Olin College.

A New Transdisciplinary Program

To help strengthen the top of the “T,” required learning experiences

(a term we have adopted in lieu of the term "courses") we have designed take on a transdisciplinary feel, where the term "trans" disciplinary is intentionally used instead of "multi," where the effects of working on a problem are additive rather than integrative, or "inter," where the work tends to be more integrative, but the fields or disciplines collaborating tend to be close to each other, like chemists and biologists (Petrie 1992). Transdisciplinary teams of collaborators on the other hand tend to come from widely varying fields, from science and engineering to business, and then also perhaps philosophers and fine artists to help the team empathize with the more human and social aspects of the task at hand. The tasks at hand tend to be wicked, open-ended problems with many possible solutions, or none at all.

Students are required to enroll in transdisciplinary learning experiences each semester. These experiences account for approximately 33 percent of the student's plan of study. Currently two experiences exist, one in a "studio" setting where problems are addressed as projects from the perspective of the scientist or engineer. The other is set in a "seminar" pedagogical style, where the same, similar, or completely different problems are addressed from the lens of the liberal arts. Each year's experiences are focused on what we have identified as "phases" of development:

- **Guided Exploration**—Where students are guided and encouraged to explore different areas of study, while being encultured with the idea of themselves, their passion, and competencies.
- **Formation and Immersion**—Where students formulate their plan of study, and begin to immerse themselves in the transdiscplinary variety of disciplines they have explored. During this phase they focus on practicing developing competencies that will cut across the disciplines.
- **Deep Immersion—**Where they focus on their individual strengths, practicing and developing personal and

discipline-specific competencies.

- **Capstone and Future Planning—**Students participate in a year-long capstone experience while developing a plan with milestones on their future learning.

Often the curricular theme is consistent between the two learning experiences, for example, wrestling with the problem of human waste on the planet.

While examining problems in these transdisciplinary settings students also create and curate electronic portfolios (eportfolios) containing artifacts that are used to demonstrate their level of proficiency across eight broad primary competencies (Figures 6.2 and 6.3). Our definition of competency is consistent with best practices in that they are:

- Developmental, meaning they are teachable and cumulative
- Integrated, consisting of multiple components—knowledge, skill, attitudes, values, and behaviors
- Transferrable, across many roles and settings in life
- Public, continually re-evaluated and re-defined

The eight primary competencies in our transdisciplinary program - currently are

- Design Thinking
- Systems Thinking
- Innovation and Creativity
- Effective Communication
- Ethical Reasoning
- Social Interaction on a Team

- Envision and Execute Independently
- Apply Disciplinary Knowledge

Each of the eight competencies is comprised of several sub (performance-level) competencies. For example, Design Thinking includes performance-level competencies such as "idea fluency" which embraces empathy, and "entrepreneurship" is a performance-level competency in the Envision and Execute Independently primary competency. Each of the performance-level competencies are further defined in three developmental stages as shown in Figure 6.1. These are accounted for using digital badges (Evans et al. 2015; Ashby et al. 2016). Students must satisfy all developing level sub-competencies, however they have varying degrees of choice as they acquire proficiency. For example, students might be required to attain emerging level competency in two of the five sub-competencies shown in Figure 6.1 and then choose two more of the remaining three. Again referring to Figure 6.1, they may be required to gain proficiency in one sub-competency but then must choose two (or more). The combination of sub-competency attainment then is what makes up satisfying the primary competency.

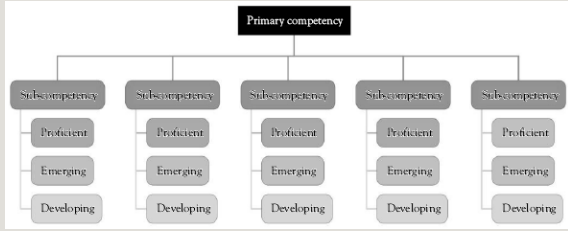

Figure 6.1 Competency hierarchy

A Faculty Perspective

Systemic change is difficult. One of the greatest challenges of such revolutionary change is faculty letting go of portions of their expertise in order to focus more time and energy on new roles, such as coach and mentor. Rather than instructing, faculty become

facilitators, requiring more skill in formative assessment that looks more like face-to-face critique. This can be both frustrating and rewarding. Perhaps one of the most satisfying aspects of this work to date has been observing when students begin to make connections between knowledge and skill developed in discipline-specific classroom environments and demonstrating what they can do with what they have learned by combining distinct learning fragments into cross-cutting competency, such as analytical reasoning and critical thinking.

The faculty dedicated to this program have learned to work in transdisciplinary teams, meaning that scholars from widely varying fields have learned to better appreciate each other's perspectives on knowledge, it's attainment, and assessment. This has resulted in a unique formation of camaraderie among the faculty, many whom are putting promotion and tenure at risk. This is not to say that we do not from time to time fall back into our "expert" biases. We do, however, know we are better equipped to "notice" when this is happening, and take corrective action, even if that action means postponing contentious conversations.

A Student Perspective

Each year students participate in surveys and focus groups to provide feedback for continuous improvement purposes. Often it is the case that feelings of their contributions, and the concept of practice until mastered surface as ideas or themes on their experiences in the transdisciplinary program. The notion of practice, of doing something over, is often lost in education, where assignments and assessments are "one-time," a grade is given, then all students move on. The idea behind competency-based education is that one does not move on until competency is satisfied. Co-author Aubrey (AJ) Hocker summed up these two ideas this way:

When I think of my last semester and how I felt about the people in the program all I get is a sense of family. I don't see the other

students as strangers who happen to be taking the same classes. We all put our interests into each project and share the learning experiences, both good and bad. However, when I say bad I don't mean in terms of failure. I know this as a stepping stone on the road to learning.

With so many other classes It becomes a pass or fail scenario. You try and take a quiz or write a paper and if you don't do well on the first try then your grade permanently drops below an "A." Even if you improve to the next quiz or write a better paper the second time your grade still cannot improve from the mistakes than were made. In this program your learning is rewarded. I believe than this is the point of school and I get that feeling every time I come to class. Failure is ok, it's essentially mandatory so than each person can grow. If we do not reflect upon our failure then we cannot learn from it. Yet, if we were to do so and there was not a way to reward our efforts at comprehension then what incentive would there be?

Another area where students have needed to adapt is in the area of having artifacts of learning made public. In traditional education systems, the credit hour is the known currency and grades reflect a summative evaluation. While highly scalable the system suffers from a lack of information as to what was learned and transparency showing what student learning looks like, as evidenced in traditional transcripts. Students in our program create and curate their own ePortfolio, which they can show to potential employers and continue to curate throughout their life if they so choose. Figure 6.2 shows the portfolio home page of co-author AJ Hocker, while Figure 6.3 goes deeper into the portfolio, providing an example of how content from projects and assessments can be added.

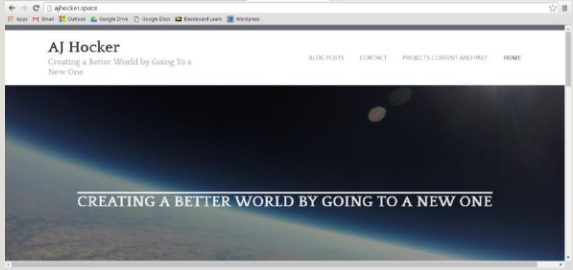

Figure 6.2 Example ePortfolio home page

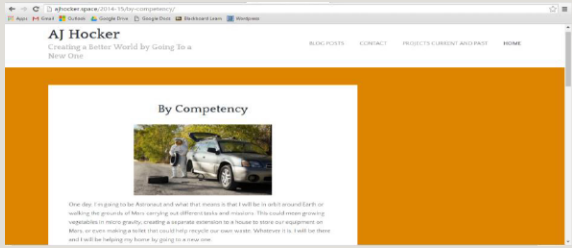

Figure 6.3 Example ePortfolio content page

In this new program all of the assignments, the many ways of learning, and ultimately the student are a work in progress, and it's hard to do. But there is a different reason that it is difficult. This is a new program with many different aspects to it that are not inherent to k-12. Students initially had a hard time adjusting to the idea that they can fail at something but be succeeding at the same time. It's against any test score or project grade. It is also hard because everyone is still working out the kinks in the system.

Each project is fluid in state, especially when each person has different skill levels in different areas that have to work together on a project in which they need to work together. It is sometimes very hard to wrap their heads around it. Students began to realize the difficulties instructors had with trying to assess student growth when there are so many areas to check. However, for many, when the project is under way they start seeing the connections that were shown in the beginning. Students got to see first hand, and by their own hand, how they are supposed to apply the skills that are

presented.

I see assignment in this program a different way now. My friends are in it, my teachers know me like a friend and I put my own interests into each project. I can even see myself grow when my teachers check in on the progress of our project throughout the course. We have a chance to explain our difficulties and our solutions than we have found or even have them help to steer us in the right direction. In a sense, the project are truly mine, not some textbook suggestion than you follow like IKEA instructions.

Within this relationship there is a sense of trust than I do not feel in most other courses in a traditional setting. In a traditional scenario the professor is seen as an all knowing opponent trying to trick the students into giving the wrong answer through clever wording and long tests. If the faculty member doesn't know the answer they will try and stall or make up an excuse as to why it is not pertinent to the conversation. In an essence they spin it into their own favor. The biggest factor within this relationship is trust.

In this program my teachers tell me when they don't know or understand something. From here, instead of dropping the matter they say, "ok, let's find a way to answer this." The only boundaries we have are the ones than we set ourselves derived from our determination and curiosity, how far we want to go with it. It's no longer the students versus the professor for a grade. It's teachers caring about their students and working with them to learn and comprehend.

Future Directions

Our first cohort of students began in the fall of 2014. In the two years that have passed the entire team of faculty, administrators, consultants, students, and parents experienced multiple instances of frustration and anxiety, along with rewards and euphoria, especially on the day we learned our degree program was approved by our regional accreditor.

One of the characteristics of our endeavor is maintain agility. As such we are constantly reviewing ways to improve. We recently combined our design lab studio course and seminar course into a single learning experience. The motivation is three-fold:

1. To remove perceptions of bias between the two courses in terms of both credit hour and contact hour requirements,
2. To allow for more rapid, approaching instantaneous change in pedagogy depending on the state of the course at any instant in time, and
3. To make room for a more deliberate, credit bearing experience focused solely on the design and implementation of the student's ePortfolio

We are also constantly reviewing all of our competencies. As previously mentioned, competencies are public, and as such we recognize the importance of re-evaluating them from their names, descriptions, and developmental thresholds (the description of what a competency "looks-like" when attained at each developmental level). As these are refined, so to are their assessments. Finally, any curricular scaffolding that we feel needs to be placed in our learning experiences will be completed.

We see the Transdisciplinary Studies degree as one of the first of several key steps in our transformation from the College of Technology to the Polytechnic Institute. We are redefining the idea of a Polytechnic to serve the needs of society and employers who are now emphasizing their need for graduate who are technically competent yet well prepared for the 21st century "thinking" or "conceptual" economy.

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CHAPTER 7

Preparing the Curriculum to Prepare T-shaped Professionals

Gary R. Bertoline[1]

Abstract

The Purdue Polytechnic Institute is a bold initiative to address many of the pressing challenges facing higher education in this digital age and provide a better-prepared STEM workforce for our nation through the transformation of traditional teaching and learning practices. It is attempting to transform higher education from within by changing an entire academic college with a total of 5,000 students, 250 faculty, and 200 staff in West Lafayette and nine locations around the State of Indiana.

Keywords

curriculum, higher education, STEM education

Acknowledgments

We are guided especially by the works and research of the Association of American Colleges and Universities (AAUC) on “essential learning outcomes” which are best developed by a liberal education and their Key Findings from 2013 Employees (AAC&U Essential Learning Outcomes n.d.; Hart Research Associates 2013). These essential learning outcomes are delivered through high impact teaching practices.

Introduction

There are four fundamental factors that collectively drive the need to transform higher education around the theme of the T-Summit 2016 (Arum and Roksa 2010; Augustine 2005; Eyring 2011; Wagner 2012).Taken collectively, these four factors warrant transformational change:

- The economy has changed, having moved from an information era where knowledge is the main capital to a thinking economy era where integration, innovation, and unstructured collaborative problem solving are key skills. To be relevant, curricula and instructional frameworks cannot exist as stovepipes or simply serve as brokers of knowledge.
- The students have changed. Students of the current generation are different in what they know, how they learn, and what they aspire to. Instructional techniques must not continue fundamentally unchanged as they have for decades.
- The needs of companies have changed; companies are explicitly reporting that college graduates are not satisfactorily meeting industry needs. Colleges that demonstrate academic nimbleness and are responsive to the calls from companies and communities will emerge as state and national leaders.
- The place and role of higher education in society is changing. Youth and their parents see a college degree as an intrinsic component of their intellectual, civic, professional, and personal development, while new and competing choices are emerging as the value of higher education is being closely scrutinized.

Body

The Purdue Polytechnic Institute's transformation plan focuses on

six intersecting areas with a goal to have most of our work completed by Fall 2017:

1. Curriculum Innovation
2. Teaching and Learning Method Innovation
3. Use-Inspired Research
4. K-12 STEM Education and URM Opportunities
5. Faculty Professional Development
6. Modernization of Learning Spaces

Curriculum Innovation

Curriculum innovation is being driven by the needs of industry and delivered through curriculum and learning transformation that prepares a T-shaped professional. The curriculum is being transformed through new application-oriented degree programs and options where students learn the fundamentals or theory of computer science for the computing-related degrees, engineering fundamentals for the engineering technology degrees, and fundamentals of business and management practices for the applied management degrees. Students then learn how to apply the discipline fundamentals to specific applications in their respective fields and industry sectors that are growing rapidly, such as advanced manufacturing, computing and information technology, construction, and aviation. These distinctive degree programs are to prepare a workforce in the STEM disciplines for the digital age where graduates learn by doing and are measured for success by "what they can do with what they know" through competency-based instruction.

The overall goal is to prepare graduates as T-shaped professionals. T-shaped professionals are characterized by their deep disciplinary knowledge in at least one area, an understanding of systems, and their ability to function as "adaptive innovators" and cross the boundaries between disciplines.

The vertical bar of the "T" represents the disciplinary specialization

and the deep understanding of one system. Systems describe major industry sectors, such as transportation, energy, design and manufacturing, food, and health care, that impact quality of life. The defining characteristic of the "T-shaped professional" is the horizontal stroke, which represents one's ability to collaborate across a variety of different disciplines.

The "T-shaped" graduate has the combination of deep "vertical" knowledge in a particular STEM domain with a broad set of "horizontal" skills such as teamwork, communications, creativity and problem solving, facility with data and technology, an appreciation of diverse cultures, and advanced literacy skills. These horizontal skills are gained from internships, co-op programs, community service learning programs, study-abroad programs, undergraduate research programs to supplement coursework, and the integration of humanities in the curriculum. The humanities are being taught in an integrated fashion in their major courses so that these topics are viewed by the student and faculty as being integral to the learning of their discipline rather than simply as "general education."

Teaching and Learning Innovation

Based on learning theory and effective use of technology, teaching and learning practices are being changed to better deliver instruction and improve the learning experience for the student. Teaching and learning practices being implemented in the Polytechnic include:

- Theory-based applied learning—core to the Polytechnic learning experience, applied learning is a powerful lab-centric approach that helps students understand and retain concepts to solve problems.
- Team project-based learning—team projects are a cornerstone to the transformation, exposing students to team dynamics, team deadlines, and team problem-solving. This is particularly effective when implemented through studio and design lab learning spaces.

- Modernized teaching methods—instruction transitions toward a model known as “active learning” that place students at the center of the learning environment with faculty serving more as mentors and coaches. Advanced methods, such as “Learning in Context,” provide a richer learning experience that synchronizes the purpose and timing of specific learning topics.
- Integrated humanities studies—through integrated humanities study and using learning-in-context methods, students will learn horizontal attributes of the T-shape to become better communicators, team participants and leaders, and creative problem solvers.
- Competency credentialing—measuring students level of learning by showing what they can do and less emphasis on test taking.
- Senior capstone projects—students have real projects with real clients that span two semesters providing a very deep learning experience.
- Internships—embedding internships into the curricula to expand student knowledge and skills in a real-world setting and set a solid foundation for employment after graduation.
- Global Cultural Immersion—students can choose to gained enriched global perspectives through study abroad, international internships and senior capstone projects, or other types of global projects.
- Faculty-to-student mentorship—Polytechnic students will be paired with faculty and staff members for professional guidance and support while a student at Purdue.
- Business practices and principles—students learn the foundations of business practices, such as finance, marketing, sales, and HR.

Application-Oriented (Use-Inspired) Research

The transformation of the Purdue Polytechnic Institute from the College of Technology is a major undertaking that affects all aspects of a contemporary higher education academic college. Much of the publicity surrounding the transformation has been focused on the transformation of the undergraduate curriculum. Research is a core component of the Polytechnic now and will continue to grow into the future. The college has a unique role to play in research at a R1 university in the 21st century.

Research in "science" is the discovery of new knowledge, research in "engineering" is the creation of new artifacts, and research in the "Polytechnic" is the discovery and implementation of new solutions through the integration of science discoveries and engineering artifacts. Use-inspired basic research is undertaken to understand fundamental laws and principles, but the inspiration of such research is not to create new knowledge but "to solve practical problems." Industry has a high interest in this type of research, and we are seeing that interest grow with 55 percent of the college's $21 million in research awards last year coming from industry. This practical problem-solving approach aligns perfectly with the undergraduate curriculum goals and provides rich opportunities for undergraduate students to engage in research.

K-12 STEM Education and URM Opportunities

The Purdue Polytechnic Institute recognizes the need to better prepare K-12 students for college and work in high-demand STEM fields. The Purdue Polytechnic Indianapolis High School is a new charter school specifically designed to develop a new generation of skilled talent by seamlessly transitioning students from high school and postsecondary education to high-wage, high-demand jobs with a focus on preparing underserved students. This will be unlike any educational experience offered in Indiana and, potentially, the nation. The rigorous curricula and learning environment are built on strong industry relationships, an innovative partnership with the Purdue Polytechnic Institute and Purdue University, and the local

community with a goal to ensure a diverse student body succeeds in the digital economy.

Faculty Professional Development

Faculty are going through an extensive development program to change their teaching from "sages on the stage" to "coaches and mentors." All faculty will be going through the university's IMPACT program as well as specialized workshops and mentoring to address the specific challenges we face in transforming the learning experience for our students.

The leadership team for the college is also going through an extensive development program to increase collaboration and trust within the group.

Modernization of Learning Spaces

A transformed learning environment requires transformed learning spaces. Since there is less emphasis on lectures and more on active and collaborative team-based learning, the learning spaces have to change to a more open-space architecture to accommodate small-team gatherings. Space is being remodeled in Knoy Hall, and a study is currently underway to finalize additional space needs in support of the transformation and to identify potential space solutions.

Conclusion

In August 2013, the Purdue University President and Board of Trustees designated the transformation of the College of Technology into the Purdue Polytechnic Institute as one of the Purdue Moves. The transformation offers extraordinary opportunities to students and faculty and touches all parts of the college—curricula, learning/teaching methods, learning spaces, student assessments, use-inspired research, industry and community engagement, and nearly every fiber of the college's culture. The transformation represents not only a change in what the college does, but also a change in how the

college does it with a goal to create the T-shaped professional prepared for the challenges of the 21st century.

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PART III

Employer Perspective

CHAPTER 8

Management Perspective—For T-Employees to Flourish: Be Mindful of the Culture You Immerse Them In!

Michelle Grainger[1], Timothy L. Michaelis[2], and Paul Mugge[3]

Abstract

Universities around the world are making significant investments in providing students with cross-disciplinary programs designed to build both their technical and social skills. This balance of skill sets is exactly what companies are seeking in new employees, yet the culture of these organizations may actually thwart the energy, creativity and overall effectiveness of these new T-employees. Managers should take heed of this and make special efforts to establish a "culture of innovation" that inspires and motivates new, and more-seasoned, employees alike. This paper offers managers a way to measure and manage the organization's culture. In addition, the authors show how advanced analytics may be used to understand the range of results that typically occurs with employees from various business functions, time with the firm, and so on. This detail is important if managers are to put in place hard-hitting remedial actions that don't paint all employees with the same brush.

Keywords

culture, employee onboarding, employee retention, innovation, T-student

Acknowledgment

Karen Patch, SAS Institute, for her assistance in applying advanced analytics to visualize the diversity and range of innovation subcultures that exist within an organization.

What Is a T-Employee?

T-Employees are the product of institutions of higher education across the world. As attendees of T-Summit 2016, we were impressed with the great number of programs institutions of higher-learning have initiated to groom T-Students. In his key note address, Experiential Learning and Creating T-Shapes, President Tim Sands (Virginia Tech) explained to attendees the ways that educational institutions will have to adapt to prepare students of the future. He further described how Virginia Tech is modifying the T-shaped student model to a "VT-shaped student" model, which brings in experiential and communal learning. "We want to prepare students who can tackle the complex global problems and opportunities of the future," said Sands. "To do that, students need to be adaptable, resilient, and culturally competent."

Rebecca MacDonald (Cornell University) described a novel program, called Stimulating Creativity, Entrepreneurs and Leadership Skills that begins the development of T-Students at undergraduate level. And, Paul Maglio (University of California—Merced) explained how he and his colleagues are building T-Student business program from the ground up. When complete, Paul believes Merced will have the first T-Shaped Management Curriculum in the nation. In their World Café session, "One Size Does Not Fit All," Collin Potts and Michelle Tullier (Georgia Tech) gave an overview of what their university is doing to develop T-Students, pointing out that some of their initiatives have a liberal art emphasis; while others are STEM intensive.

No matter which direction they approach the challenge, every institution we heard from is providing T-Students with experiential learning opportunities, where they (a) work in empowered, cross-disciplined teams, (b) think critically and creatively about the problems presented to them, and (c) freely express and defend their ideas.

Federal funding agencies, a major source of prestige and resources for many of these same institutions, also promote the development of T-Students. The new NSF Research Traineeship (NRT) program is designed to "encourage the development and implementation of bold, new, and potentially transformative models for STEM graduate education training" (Program Solicitation NSF 15-542). The NRT program includes two tracks: the Traineeship Track and the Innovations in Graduate Education (IGE) Track**.** Both tracks help to ensure that graduate students in research-based master's and doctoral degree programs develop the necessary skills and competencies needed to succeed in a STEM career. NRT Traineeship Track Awards (10 anticipated in 2016) are expected to be up to five years in duration with a budget up to $3,000,000;

NRT IGE Track Awards (14–20 anticipated in 2016) are expected to be up to 2 to 3 years in duration with a budget between $300,000 and $500,000. For U.S. institutions, NRT will serve as a powerful tailwind for promoting the development of T-Students and future T-Employees.

The Center of Innovation Management Studies (CIMS) at NC State University helps develop future T-Employees as well. CIMS was founded in 1984 by the NSF and the Industrial Research Institute. As one of the first IUCRC (Industry-University Collaborative Research Center) its mission then, and to this day, is to help companies better manage the innovation process, particularly those companies wandering in what is known as the Valley of Death. The Valley of Death represents a crucial point in the lifecycle of an innovation. It is in the Valley that the discovery activities of applied research and

technology demonstration must be connected with the enduing needs of customers in order to survive.

T-Employees comprise a big part of CIMS solution to these companies. CIMS interns are routinely included in all action research projects with CIMS partner organizations. Graduate student interns are offered boot camps in advanced analytics—as a supplement to their compressed concentrations. And because the Center's focus is corporate innovation, CIMS faculty and staff help run the Poole College of Management's "Value Creation Practicum." In this program aimed at the College's Professional MBA candidates, student teams work on regional companies toughest innovation challenges. They tackle questions, like what markets present the best opportunity for our technology? Who are the incumbent competitors in these markets? May these competitors also be a partner in delivering our solution? To make the teams and the overall program better we recently added graduate students from NC State's technical colleges (e.g., College of Agriculture and Life sciences, College of Engineering) Through this multidisciplinary approach, the students freely share their knowledge and experiences. Their collaboration results in much better project outcomes, and future T-Employees.

Clearly the intention of these efforts, by both academe and government, is to better prepare T-Students for what they can expect as T-Employees working in industry. But, do these efforts in reality meet the intended goals?

Business Reality Can Discourage T-Employees (and Innovation)

It is well known that the ability of companies to innovate, grow, and ultimately create value for their customers—is in large part due to the culture of these organizations (Amabile 1988; Damanpour 1991; Hargadon and Sutton 1999; Büschgens, Bausch, and Balkin 2013). Yet, in their zeal to achieve quarterly business results, management's actions can actually work counter to this. Despite significant

branding efforts to present their companies as "innovators," the dominant business design of large, established firms is "operational excellence."

The structure of these organizations reflects the emphasis they put on specialization. Functional silos form around Engineering, Operations, Finance, Customer Support, and so on, limiting collaboration and innovation. The innovation that does occur is thought to be the province of the R&D department. The scorecards of these organizations—and consequentially the compensation plan of employees—are tied to an array of financial measures (EBITDA, Profit, Sales Revenue, etc.) And first line managers, anxious to realize a "ROI" on their new employees, are given hiring authority of newly minted T-Students. As a consequence T-Employees often get pigeonholed early in their careers.

Likewise, risk taking and decision-making in these organizations take a hit. Management tends to be risk averse. Any innovations that occur tend to be incremental in nature, that is, small design and feature changes to keep current customers satisfied. No resources, or attention, are given to big innovations, the type that create entirely new markets (and the type which T-Employees so desperately want to work).

The combination of these effects creates an almost perfect storm that has a desultory effect on employees. By not tending to the organization's culture, management can suppress T-Employees—and snuff out innovation and growth.

A Healthy Culture Is Key

But just how can management create a culture of innovation where T-Employees will flourish? The common belief is organizational culture is too complex and that no one understands how organizational culture works, or how in the world it relates to business results. The truth is over 45 years of research; done by different scholars and with numerous companies, shows us how

culture works. And most importantly, there is a definite link between organizational culture and innovation, company growth, public reputation, market share, and employee engagement.

For some managers, and indeed some whole companies, this truth may not be enough. Many still hold on to old precepts of exactly what innovation is and how it is accomplished. They constantly confuse innovation with invention, and believe innovation comes from a lone genius or at best from small, sequestered teams that vanish from sight, then return with big ideas. The myth of the lone genius dies hard! (Hargadon and Sutton 1999; Drucker 2014). To the contrary, innovation is a full contact, team sport—exactly what T-Students were trained to play in college! It involves all the business functions, for example, Sales, Marketing, Operations, and Customer Support, as well as R&D.

The confusion over what exactly innovation is—and isn't—leads to misleading measures. Some popular misleading metrics of innovation that we see companies use are R&D Intensity and the # Patents Issued. The latter is our favorite. As far back as 1851, The Economist argued that "patents are like lotteries, in which there are a few prizes and a great, many blanks." The problem, primarily, derives from the huge gap between the expectations of the individual inventor (patentee) and the overall results of patent exploitation and commercialization. It is estimated that less than 80 percent of patents worldwide are utilized (Pugatch 2005). Even worse, most of the patented technologies are worth less than their registration and maintenance fee (Pugatch 2004). Getting the definition and measures of both organizational culture and innovation right is critical. After all you can't manage something, if you can't measure it.

The VIQ: A Tool for Managing Both Culture and Innovation

CIMS has a valid and reliable diagnostic tool for measuring and managing a "culture of innovation." It is built on the premise that

culture is embedded in behavioral practices that can be assessed with both quantitative and qualitative metrics. Hence, culture can be described, explained, predicted, and managed.

In 1999 the Industrial Research Institute's (IRI) Research on Research (ROR) committee concluded that focusing on the development and commercialization of new technologies is not enough for an organization to be truly innovative. Rather, innovation needs to occur across the full value chain, including marketing, sales, operations, distribution, and service—in addition to R&D. They determined that "value innovation" occurs when organizational members are working on identifying better (new) ways to serve their current customers and are identifying new markets.

CIMS Researcher, Dr. Lynda Aiman-Smith led the research team that developed definitions of value innovation concepts and statements that would measure those concepts. The measures drew from previously published theoretical and empirical research, as well as the experiences of ROR members. A large number of possible survey items (statements to which people can respond) were generated for the tool and reduced using a number of statistical techniques. The result was an easy to administer tool that assesses 9 key dimensions of culture by answering just 33 questions. Respondents are asked to rate these questions on a scale of 1 to 5, where 1 indicates respondents "Strongly Disagree" that the particular behavior reflects what they see happening in the organization, and a 5 indicates respondents "Strongly Agree" they witness the behavior. (To see the complete list of questions and to understand the VIQ better, please read: Assessing an Organization's Potential for Value Innovation, Aiman-Smith et al. (2005), on CIMS website https://cims.ncsu.edu/tools-assessments/value-iq/)

Dr. Aiman-Smith would be the first, however, to stress that the resulting assessment tool is not exhaustive, it does not measure everything that can possibly lead to innovation. But rather it is a tool that can reliably and validly measures important aspects of an

organization's potential to innovate—providing management heeds its prescription. For example, we know that individuals whose work is meaningful, and who have autonomy to make decisions and speak out about issues, are more innovative. We also know that being open to change contributes to innovation. Cultures where it is permissible to take risks and learn from failures contribute to innovation. Business planning, business intelligence and decision-making affect innovation in organizations, while organizational structures that support communication and facilitate learning also contribute to innovation. Why would management not want to instill these practices instead of those that suppress innovation and T-Employees?

Figure 8.1 shows the results of working with one company for three years on their culture of innovation. The VIQ assessment was taken by thousands of employees worldwide. You can see that the category of **Customer Orientation** (3.9) is a relative "strength" of this organizations culture, followed closely by **Meaningful Work** (3.6). While management concedes that it has more work in front of them, the organization is exhibiting behaviors that will allow innovation to flourish.

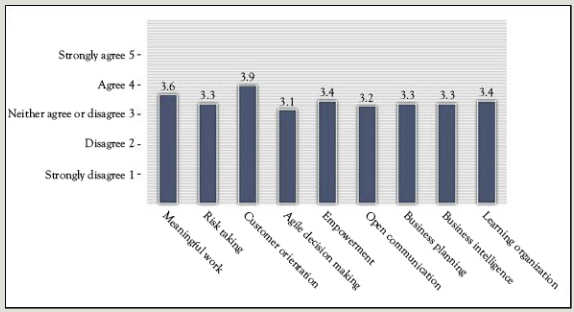

Figure 8.1 VIQ dashboard

CIMS has administered the VIQ to scores of organizations. Its outputs are reliable and proactive. We believe it is the best measure of the ability of organizations to innovate and create value.

Going Beyond a Simple Quotient

The VIQ also captures rich demographic information that is, Geography (Nationality), Time in the organization, Business Function, and Position (Title) for each respondent. At one level these groups represent the subcultures that exist in all organizations. It stands to reason that these groups of people might see the culture of the organization quite differently. Any change plan to improve culture must take into account these differences.

Working with SAS Institute we are mining over 10 years of VIQ data using their new SAS Visual Analytics product. SAS Visual Analytics provides us—and CIMS member organizations—with the ability to examine these subcultures. The software allows us to visually explore all data, discover new patterns and publish reports to the web and mobile devices. It automatically highlights key relationships, outliers, clusters, and trends to help explain why something happened. In a word it provides management with a much better "grasp" of the organization's culture.

Analytics provides us with important cuts of VIQ data. Figure 8.2 shows the perception of **Individual Contributors** (Position), working in different **Business Functions**, to the VIQ category of **Agile Decision Making**. T-Employees are keenly aware of management's actions, particularly their ability to make decisions. They are also aware of how the decision was made. They watch who is empowered to make decisions and the depth of analysis used by these people in arriving at a decision. Research on decision-making shows that gathering and using various levels of information, and integrating diverse people and perspectives, leads to better decisions (Saaty 2004; Mohammed and Ringseis 2001; Maznevski 1994). The VIQ asks all these questions.

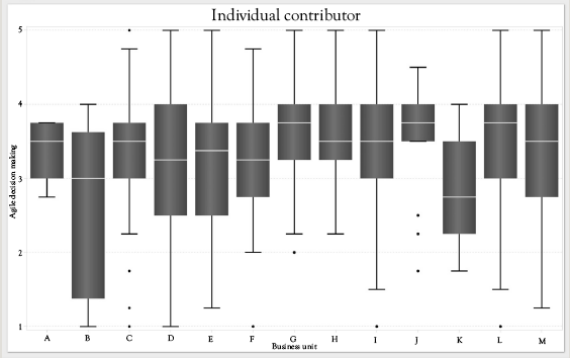

Figure 8.2 Business silo subcultures

As the box plot shows (Figure 8.2) there is a significant range of responses depending on which function the Individual Contributor is assigned. This is the effect working in a silo has on T-employees. And of course this view is looking through the eyes of individual contributors. The perception of management regarding Agile Decision Making will likely be quite different.

Another slice of data we frequently investigate is employees **Time in the Organization**. The difference between new employees' perception of the culture and those of veteran employees can be stark. Newcomers to organizations often engage in information seeking tactics in order to better understand their role and how they fit into a new organization (Miller and Jablin 1991). During organizational entry, new employees are trying to understand what their organization expects of them and what they should expect from their organization in return, that is, the formation of a psychological contract. Research shows that psychological contract fulfillment for a new employee occurs in roughly three months and newcomer information seeking during the first 2 weeks has the most impact (De Vos and Freese 2011). This means managers must act fast if they want to create an environment where T employees can thrive.

Often we see a degradation of scores after a new employee has been in the organization longer than one year. Might this be happening to T-Employees who join organizations with great expectations only to

find they are surrounded by an unhealthy culture?

Message to Management

Culture is not some academic exercise. Cultural issues have strategic and practical impact. Focusing on developing the competencies and practices that can affect the culture is a prudent use of your time and money. Tools like the VIQ and SAS Visual Analytics can make the task much, much easier.

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PART IV

Governance Perspectives

CHAPTER 9

T-shaped Professionals in Europe Today and in 2020

Werner B. Korte, Tobias Hüsing, and Eriona Dashja[1]

Abstract

The T-Summit is promoting "T-shaped" professionals as the "future ready" adaptive innovators. In Europe the T-shape metaphor is also used by industry and the European Commission, for example, to describe ICT professionals and the individuals with the skills needed to initiate and achieve digital and other types of innovation. The T-shaped professional is called "e-leader," that is, people with the skills for innovation which include the combination of strategic leadership skills, and high levels of business and digital savviness of an individual.

The present article provides a quantification of the T-shaped professionals in Europe today and a forecast for 2020. It presents an e-leadership index to demonstrate the propensity to e-leadership and the likelihood of European countries to succeed in creating the sufficient number of T-shaped professionals.

Finally, it describes the policy activity levels in this area at European and EU Member State level and ends with some first conclusions.

Keywords

benchmarking, e-leadership skills, Europe, European Commission, quantification, T-shaped professionals

Background

Disruptive business models and technology trends will generate new international market opportunities. At the same time these require the necessary skills at all levels—especially the leadership level—to put these into practice, fully exploit them and reap the benefits for Europe to become more competitive and a better place to invest and do business.

The innovation push of the current and emerging ICT and trends in STEM will generate strong transformational impacts on the EU economy and society in the years until 2020 and beyond, driving a strong increase of demand of ICT, R&D but especially new skills for innovation which we call "e-leadership skills." The demand of e-leadership skills varies by type of technology trend and type of skills, but Big Data, the Internet of Things and the combination of cognitive systems and robotics are likely to generate the most disruptive impacts and drive the highest demand for these new skills for innovation skills. Both IDC research and the experts' opinions gathered by empirica in a recent survey (Dashja and Hüsing 2016) converge on these conclusions. Approximately 70 percent of the experts surveyed agree that the increase of demand of skills will create a very high risk of skills gaps in Europe.

Actions in Europe

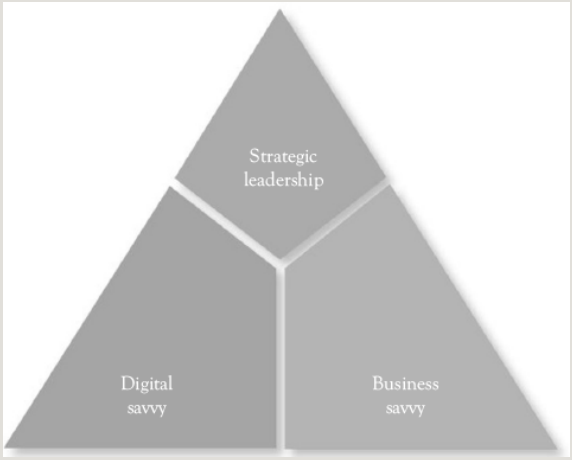
The European Commission has the ambition to ensure that Europe can be a global leader for skills and talent for digital and key enabling technologies (e.g., photonics, micro and nano-electronics, advanced manufacturing technologies). Under the EU e-Skills strategy the Commission launched the e-Leadership Skills Initiative in 2013 (www.eskills-guide.eu) which in 2014 got expanded to also address SMEs (www.eskills-lead.eu).

The judgment of the importance of talent creation is shared by many leading organizations in the world. For example, the International Society of Service Innovation Professionals (ISSIP) is promoting "T-

shaped" professionals who are "future ready" adaptive innovators. In March 2016 the T-Summit took place in Washington bringing together government, industry and academia to maximize dissemination on the latest learnings of T-Shaped professionals, and how policies, curriculum, and student and employee behavior can prepare the future workforce. (...) T Shape is a way to navigate and present individual career experience with breadth of experience (top of the T) with depth of mastery of a recognized discipline (the I of the T). The core idea is to facilitate the ability of professionals to work in collaborative teams with others in complementary disciplines and to be able to pivot with uncertainty and changing workplace requirements (T-Summit 2016).

The T-shape metaphor is used within e-Leadership Initiative when referring to and describing digital leadership (e-leadership) skills. It still uses this in addition to the presentation format of the e-leadership skills triangle. They are the skills required of an individual to initiate and achieve digital and other types of innovation.

The e-Leadership triangle:



Strategic Leadership: Lead inter-disciplinary staff, and influence stakeholders across boundaries (functional, geographic).

Business Savvy: Innovate business and operating models, delivering

value to organizations

Digital Savvy: Envision and drive change for business performance, exploiting digital technology trends as innovation opportunities.

The European Commission adopted in 2007 a Communication on "e-Skills for the 21st Century" which included a long term e-skills agenda to create a large digital talent pool for Europe to become more innovative and competitive in a global market.

Communication activities have also been launched (e-Skills for Jobs campaign: http://www.eun.org/news/detail?articleId=658886 and the e-Skills Manifesto has been published) to create the necessary awareness and perception of the need for European and national policy development in these fields throughout Europe.

Expert Opinions on e-Leadership Skills

Much broader availability of digital talent and workers and executives with e-leadership skills is seen as an absolute must by experts if Europe is to compete, grow and generate job. Europe has to address the current acute shortage of people capable of leading the innovation needed to capitalize on advances in ICT. Economic growth to create jobs requires that innovation opportunities are identified and effectively exploited. In a recent survey around 90 percent of European experts responding agree that digital savviness is crucial for leadership positions now and in the future. No expert disagreed with this view. Almost all experts believe that for companies to stay competitive in the future, leadership need to become more digital-savvy. More than 80 percent also argue that people in leadership positions require more knowledge on the possibilities that new digital technologies have to offer and even more see the need for these experts to be better at integrating digital technology in their business approach.

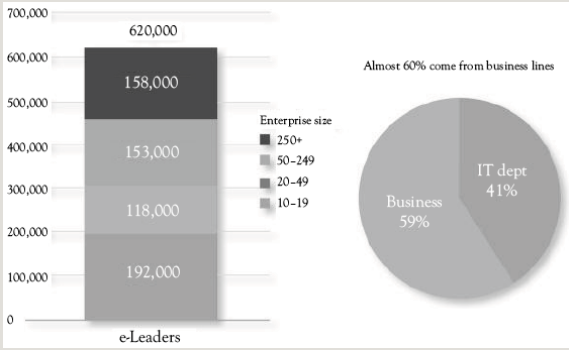
Finally, and to best prepare the future generation of professionals, more than 90 percent would like to see digital savviness integrated in

the formal educational programs in (higher and executive) education and training (Dashja and Hüsing 2016).

T-shaped Professionals in Europe 2015

While no official statistics exist to date regarding the demand or supply of T-shaped professionals which we equate with e-leader, that is, people with e-leadership skills as described previously, an estimate for the year 2013 quantifies the number of innovative e-leadership positions in Europe to be in an order of magnitude of 568,000 workers. Extrapolating growth trends to today, there are probably 620,000 innovation e-Leaders in Europe in 2015. A majority of almost 60 percent comes from the business units in companies and not from IT departments (empirica 2015).

e-Leadership quantification 2015.



Source: Empirica 2015: e-Leadership—Digital Skills for SMEs

Forecasting e-leadership demand even further into the future, we rely on estimated growth rates in analogy to the most highly skilled ICT positions. As a result demand is estimated to reach 776,000 in 2020 (Hüsing, Korte, and Dashja 2015). Europe will need 200,000 additional innovation e-leaders or T-shaped professionals by 2020, or 40,000 per year.

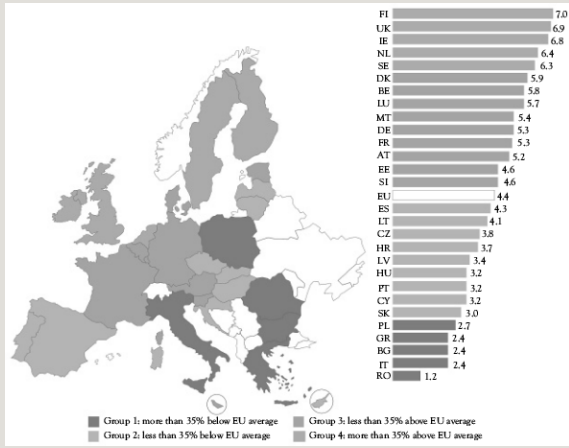
e-Leadership Index—Benchmarking EU28 Member States

The propensity to e-leadership and the likelihood of European countries to succeed in creating the sufficient number of T-shaped professionals coming up with the necessary skills for innovation varies significantly across Europe.

In 2015 empirica developed an e-leadership scoreboard which monitors progress in e-leadership skills development, covering areas of the e-leadership eco-system. The 28 indicators have been developed in an e-Leadership Index which combines each of the different dimensions of the e-leadership scoreboard in order to monitor and benchmark EU Member States. Individual countries can use the e-Leadership Index to monitor performance over time or benchmark domestic developments against other countries identify role models and start learning about how different policies may affect e-leadership practice.

The e-Leadership Index tries to amalgamate into one figure different indicators relating to the business and policy climate, infrastructure and related outcomes on e-leadership. The Index is intended to contribute to the much needed development of metrics and identifications of policies and good practices for better measuring and understanding e-leadership (empirica 2015; Hüsing et al. 2015).

European Map of e-Leadership Index quartiles.



Source: Empirica 2015: e-Leadership—Digital Skills for SMEs.

EU Member State Policies and Initiatives on e-Leadership Skills

The European Commission activities since 2007 have triggered policy and stakeholder activities on digital and e-skills as well as e-leadership skills in the different EU Member States. However, the policy level activities throughout Europe show a huge variation. These have been monitored for the first time in 2009/10 and results were published by the Commission in October 2010 (Hüsing and Korte 2010).

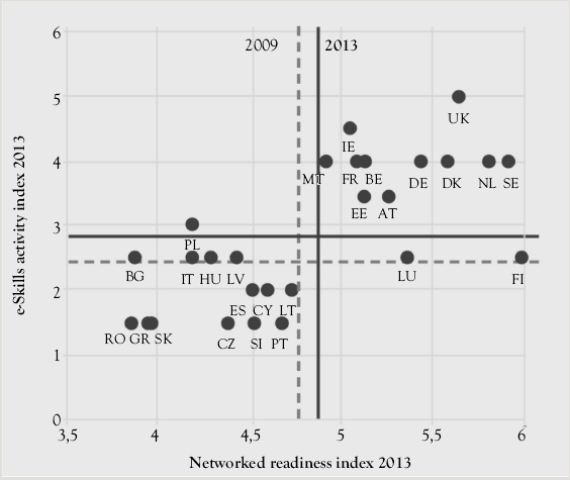
Monitoring and benchmarking of e-skills and e-leadership policies and multi-stakeholder partnerships in the EU Member States, with a special focus on education and training initiatives and policies, have continued regularly since and the latest results were published in October 2015 in a an overall report and in 28 EU Member State Country Reports. This overview reflects the state-of-the-play of late 2014/early 2015 (Hüsing et al. 2015).

A comparison of the results from 2009 to 2013 gives reason to believe that the supply situation of e-skills and e-leadership has improved over the years. This improvement is probably at least in part also a merit of an increased policy effort to set the right framework conditions, give support and incentives to develop digital skills. As one example, the average policy score that Member States got for the e-skills improved from 2.37 in 2009 (Hüsing and Korte 2010) to 2.87 in 2013 (Gareis et al. 2014) (scale 0–5). Contrasting it with the Networked Readiness Index (NRI) from the World Economic Forum it also shows that Europe becomes increasingly divided into basically two larger groups of countries with respect to policy activities: a group of countries mostly from central and northern parts of Europe being frontrunners and those from the East and the South showing less activities.

Increase of e-Skills policies scores between 2009 and 2013.

Conclusion

The present article shows that the likelihood of European countries to succeed in creating the sufficient number of T-shaped professionals coming up with the necessary skills for innovation across Europe (expressed by the e-leadership index) varies significantly. Especially the Nordic countries, the UK and Ireland and those in the middle part of the EU (especially the Netherlands, Germany, France, Belgium and Austria) but also two countries (Estonia, Slovenia) which joined the European Union around then years ago belong to the group best prepared.



Source: Gareis et al. (2014).

Policy activity levels have increased over the past years especially at European but also at national EU Member State level in a variety of countries. However, there still is a huge variation of activities across Europe with a north-south and east-west divide. But policy seems to matter since most recent statistics show that supply is increasing and that the market has started to develop a growing number of T-shaped professionals.

The quantification of T-shaped professionals has shown that Europe

will need 200,000 additional innovation e-leaders—that is, T-shaped professionals—by 2020, or 40,000 per year. Without further action to be taken in addition to those already started in the European e-Leadership Skills Initiative and by all stakeholders concerned at EU Member State level Europe will not be in a position to create the required number of 40,000 innovation e-Leaders per year. There is a job to do!

The European Commission is leading this movement with the development of a long-term agenda on "Leadership skills for a high-tech economy." It is developed in close collaboration with leading stakeholders and will include concrete recommendations for action at EU and national level to build up the supply of a comprehensive range of e-leadership skills and ensure their future optimal availability throughout European enterprise.

All stakeholders—companies, industry and professional associations, social partners, all levels of European and Member State government, educators and trainers, and individual citizens—have a role to play.

They will meet at a high-profile conference on January 26, 2017 in Brussels.

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PART V

Defining and Measuring the T

CHAPTER 10

Developing the Connective Tissue of the T

Gordon Rowland[1] and Jason Hamilton[2]

Abstract

The Ithaca College faculty has created an integrated core curriculum that requires students to select among five themes and to take four courses that represent different perspectives of their theme. This is intended to help students empathize with multiple viewpoints, for example, to come to know how perspectives differ in terms of epistemology, methods, and assumptions.

We believe that, while the courses succeed in introducing multiple, distinct ways of knowing, they do not sufficiently prepare students to make connections across. In other words, they lead to multidisciplinary, not inter- or transdisciplinary understanding, and to dotted lines in the T.

To fill this gap, we have created a set of four mini-courses called Integration, Insight, Creativity, and Character. The skills students are gaining from these courses serve as the connective tissue between the perspectives (across the horizontal axis of T), and between the theme and the student's major (between the horizontal and vertical axes).

Keywords

complexity, integrated learning, interdisciplinary, T-shape

Introduction

The ideal of the T-shaped professional of the 21st century is an important development in the long-standing discussion of the importance of breadth versus depth in professional training. As Ortega and Gasset (1932) show, concerns regarding depth without breadth are not new.

Previously, men could be divided simply into the learned and the ignorant, those more or less the one, and those more or less the other. But your specialist cannot be brought in under either of these two categories. He is not learned, for he is formally ignorant of all that does not enter into his specialty; but neither is he ignorant, because he is "a scientist," and know's very well his own tiny portion of the universe. We shall have to say that he is a learned ignoramus, which is a very serious matter, as it implies that he is a person who is ignorant, not in the fashion of the ignorant man, but with all the petulance of one who is learned in his own special line.

Still, in the context of higher education, we have seen increasing specialization spread from graduate to undergraduate programs over the past several decades, with modest general education supplements preserved primarily to meet external requirements (e.g., state requirements for certain types of degrees). Pushing back against this trend, some faculty and accrediting organizations argue that breadth is equally important to depth. This is mirrored in the growing call from those in business and industry who recognize the benefits and advantages of T-shaped individuals.

As part of an initiative to better balance breadth and depth by emphasizing integrative/interdisciplinary thinking and learning in the curriculum, we sought to develop a set of learning activities/courses that foster:

- Holistic, interdisciplinary perspectives
- Contextual application

- Creative action
- Ethic of service

Then subsequent to learning about the T, we came to see these experiences as the connective tissue across the horizontal axis and between the horizontal and vertical axes.

To this end, we have developed four short courses to help our students gain these things: Integration: Connecting the Disciplines to foster an holistic, interdisciplinary perspective; Insight: Combining Expertise to foster contextual application; Creativity: Transforming Insights into Ideas to foster creative action; and Character: Developing Habits for Good to foster an ethic of service. These courses are one-credit, pass/fail, and each involves a series of learning activities led by a pair of faculty members from different disciplines. This co-teaching environment actively models some of the important aspects of the horizontal part of the T (e.g., teamwork, communication, perspective) and helps us scale up the entire program over time; we pair new with experienced instructors to create more institutional capacity to offer these courses. The courses are fully developed with Instructor Guides, so they involve little preparation and no formal grading. They are taught over a single weekend, or once or twice per week for five weeks.

Four Courses

In Integration, we help students recognize that challenges of the 21st century do not present themselves as isolated events or problems that are resolvable through single disciplines associated with college majors or minors. Rather those challenges require that we connect disciplines in creative ways, appreciate complexity at different scales, and use the tools of systems thinking and analysis (e.g., Senge, Hamilton, and Kania 2015; Dent 1999). Over a single weekend, students in this course engage in a rapid-fire series of learning activities that help them understand the nature of disciplines —especially their own—and how those disciplines might be

meaningfully connected. For example, in an activity titled "What's my major?" students generate and compare dimensions of their disciplines: objects of concern, goals, contexts, accomplishments, limitations, language, beliefs and assumptions, and values. Many of the activities involve real scenarios, so the exploration of disciplines and disciplinary thinking happens in the context of a range of real-world systems.

In Insight, we seek to help students apply their understanding of disciplines/perspectives in the context of significant topics or issues. We choose a general topic that is broad and complex enough to require multiple perspectives, and intriguing enough to attract undergraduate students. Topics thus far have included designer genes; nation in pain; out of time; invasion and extension; water water everywhere; feast and famine; fit to eat; beauty and the beast; local versus global; living the good life; edges and interfaces; cycles in and out; revelation and revolution; world of color; lost in space; mindfulness; the other side; great escape; efficiency, productivity, and permission to waste; finding joy; known and unknown; and sound and silence.

Students interview pairs of guests from different disciplines. As an example, guests from one recent section included professors of politics, journalism, sociology, legal studies, art, music, history, and physics. After the interviews, students construct visual representations (simple systems models) that simultaneously distinguish and integrate perspectives (i.e., complexify their understanding). They do so in the context of real-world systems that are considered as the topics/issues are explored, and in a final activity they consider where in these systems meaningful change might be fostered (e.g., leverage points; Meadows 2008).

In Creativity, we take the next step, to not just understand issues through interdisciplinary lenses but to generate potentially beneficial changes and solutions. We treat creativity as a skill, so this involves a series of activities and assignments, in which we emphasize over-

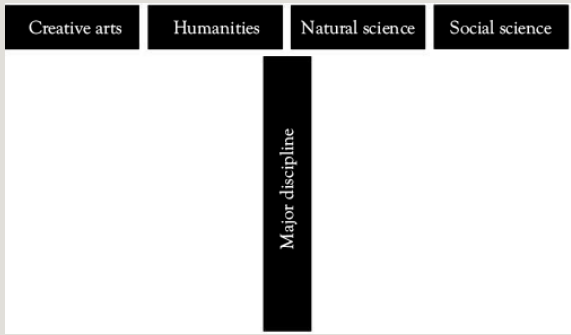
the-edge thinking (Rowland 2013). Sessions focus on different stages of a model of planned change called CHRIS (Dyer, Jones, Rowland, and Zweifel 2015), and promote design as a unique and powerful way of knowing and acting (Cross 2011; Nelson and Stolterman 2012).

In the fourth course, Character, the focus is on how we can use holistic understanding and creative action to best serve society. We consider both the content and development of character and do so at a personal level. For example, students examine the choices they make each and every day, and we offer them tools to analyze and intentionally alter their patterns of thought and action. One such tool is a learning activity called Character Map. We ask students to list traits that they are proud and not proud of in the center of a page. Then we ask them to consider the interactions and events that led to these traits and record these to the left, and how traits could be nourished or diminished to the right. This is essentially developing the "Me" in the T model, acknowledging the importance of self-knowledge and the motivation to be more creative and integrative in addressing complex issues and wicked problems. Then setting "Me" in context, other activities foster a sense that a confluence of our individual habits, thoughts, and actions has the synergistic potential to guide evolution in beneficial directions (Banathy 2000).

Results

As of spring 2016 we have offered 68 sections to over 1100 students. Our 30 instructors (thus far) come from all five schools of Ithaca College and include the dean of one school and our past provost. We have received very positive student and faculty feedback, seen evidence of application in other courses, and noticed that a culture of engagement and contribution has begun to emerge. For example, students taking a second, third, or fourth course bring an expectation that all will significantly contribute to the course, and the effort and quality of work far exceeds what might be expected for one-credit pass/fail courses.

The project has continually expanded since its beginning in 2009. A particularly important shift took place several years ago when the college adopted an Integrative Core Curriculum (ICC). In the ICC, students must select a theme from among six (Identities; Inquiry, Imagination, and Innovation; Power and Justice; Mind, Body, Spirit; A Quest for a Sustainable Future; or A World of Systems), then take a seminar and courses that represent four perspectives of that theme (Creative Arts, Humanities, Natural Sciences, and Social Sciences). Our sense is that, while exposure to multiple perspectives of a particular theme is valuable, simple exposure does little to help the student make connections. Hence, for us the ICC creates a T-shape, but with a dotted horizontal line, and a disconnect from the vertical bar (see the following figure). We believe our mini-courses fill the gaps and thus serve as the connective tissue of the entire T.



Directions

Our provost has asked us to expand this program at the college. Over the next two years, we are doubling the number of sections we offer, expanding from six to twelve per semester. Based in part on our experience at the T-Summit we are considering adding other courses: one focused on teamwork/collaboration (and we've wondered if the individual is a T, then what is the shape of a team?), and another specifically targeting integration within each of the ICC themes. We are seeking to incorporate new developments, like the concept of grit in Character (Duckworth 2016). To supplement the continuous improvement realized through student course evaluations, instructor

feedback, and Instructor Guide revision, we are developing an approach to assessment that is based on assumptions of complexity. For this purpose, we initially began to develop a tool that combines the AACU VALU rubric for integrative learning, with Student Learning Outcomes from our Integrated Core Curriculum. We soon recognized that this was perpetuating a view of learning as a simple system, and we are now exploring alternatives that respect the complexity of learning, for example, the notion of intelligent accountability (Ellison 2012).

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CHAPTER 11

MyT-Me—Your Personal T-Shape Scoring System

Louis E. Freund[1]

Abstract

This paper presents a schema for reflecting a person's professional and personal background, accomplishments, and experiences in a manner that is quantitatively indexed in a scoring system related to the definition of the T-shaped professional. Sub-metrics for the T-top score and the T-stem score are discussed. An example graphic report of an Excel-based tool to display the results of the assessment is presented.

Introduction

The concept of the T-Shaped professional has been widely discussed (see, for example: http://tsummit.org/t). It is agreed, generally, that having depth in a specialization or discipline, as well as breadth in experiences across multiple systems, cultures, leadership roles and other experiences moves a person further and further in the direction of being "T-Shaped." The graphic in Figure 11.1 has been used extensively to represent this concept. Depth in the discipline forms the "stem" of the T, while breadth across systems, cultures, and experiences forms the "T-Top."

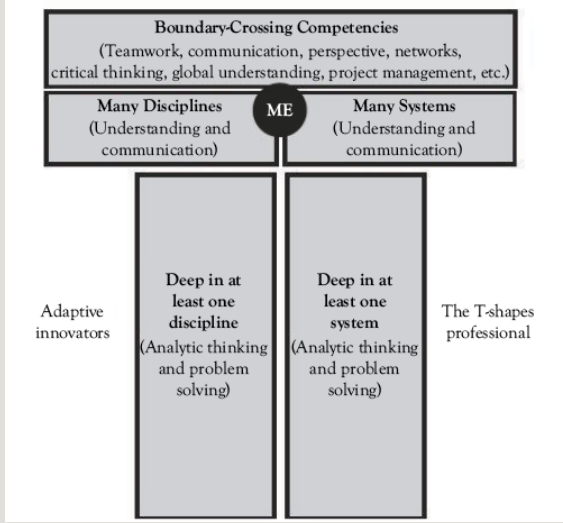

Figure 11.1 T-Shape model

Yet, the presentation of the model also raises the question: "How T-Shaped am I?" That is, we are all T shaped to some degree, and certainly some are more T-Shaped than others. This paper discusses a T-shape metric called MyT-Me™, which aims to provide a comprehensive scoring system for any professional to develop his or her own T-Score based on his or her experiences, accomplishments, and activities. Data from your vita is initially entered into forms named MyHistory, MyRoles, MyDeeds, MyTools, MySkills, and MyPoints. Information from these forms is extracted for the MyT-Me™ metric.

Of course we must begin by realizing that T-shape metrics change regularly. We are T-shaped to some extent at the beginning of our professional careers. As we have professional experiences, our T-score increases (never decreases). Thus, our T-score can be viewed as a point in time measure; but over time, it can provide a longitudinal assessment of our professional life, and interval scores will describe our professional T-shaped trajectory. Having such a system will be important, since in addition to the question posed earlier, people also want to know how they can become more T-shaped; that is, what contributions alternative activities might make

to their T-score so they can choose and plan their professional growth with a perspective of the relative values of present choices. Similarly, maximizing the attributes of teams relative to the T-shaped characteristics of its members is an appealing proposition for many companies.

Metric for the T-Stem

In discussing the "T-Shaped person," the Stem (or vertical bar) of the T is taken to reflect depth in the profession. Experiences such as education, training, skills, competencies, certifications, and similar evidences of professional knowledge are included, and are organized as follows with regard to the contributors to the Stem:

S-1. Memberships, authorships, and recognitions

Each professional organization membership is counted in the T-Stem score, as are membership ranks, such as Fellow. Publications in reviewed or refereed journals, culminating projects, theses, and so on are also included. Attendance at national or international professional meetings, as well as making a presentation, or co-authoring a presentation at such a meeting contributes to the T-Stem score. Finally, in this category, activities such as applying for or winning grants, winning competitions related to professional work and similar recognitions reflecting competency in your professional practice are counted in this portion of the score.

S-2. Education and degrees and certifications

Depth in your profession is certainly evidenced by your educational achievements in school, certifications, and licensures. In this section, each earned degree, is counted, even those in additional fields of study, as well as state or federal certifications and state or federal licenses to practice. However, shorter interval educational programs such as workshops and individual semester courses also are included. Finally, we always learn and improve our professional depth when teaching a topic; so, conducting briefings, lectures, workshops or full

semester courses also are recognized in the T-Stem score for their contributions to our professional depth.

S-3. Operations responsibilities and expertise

MyT-Me™ considers your operations responsibilities to be reflective of your experience and depth in your profession. In that regard, your experience over your career in selecting locations where people or systems for your organizations do business physically or on line, selecting equipment and the tools needed to get the job done, selecting and managing labor resources in your organization or unit, and determining processes, assignments, deadlines and procedures all build up your T-Stem score in the MyT-Me™ metric. Further, to have been recruited for role on a team or for a consultant or full time position, or to be qualified as an expert witness or recruited for a role as a panel member, author, or speaker are also evidences of expertise and recognized in this portion of your T-Stem score.

S-4. Software/Device Proficiency

Software and device proficiencies that you have skill or knowledge in using are identified on the MyTools form in the system. Your current proficiencies are self-rated from Basic to Expert. Your level of experience and proficiency with each software and device you list in the system are valued, and if you have achieved a “certified” or equivalent status and/or used the software or device professionally in the last 12 years, the value is enhanced in your T-Stem score.

S-5. Methods/Skills Proficiency

Analytic, design, business, clinical, or other methods or skills that you have knowledge in using are identified on the MySkills form in the system. Your current proficiencies are self-rated from Basic to Expert. Your level of experience and proficiency with each method or skill you list in the system are valued, and if you have achieved a “certified” or equivalent status and/or used the method or skill in a project or position in the last three years, the value is enhanced in your T-Stem score.

Metric for the T-Top

Nine dimensions are assessed to form the T-Top metric. They are:

T-1. Project management—Points are accumulated across activities and experiences such as coordinating a multi-participant writing project (such as a joint report, journal issue, or book), performing a leadership role in a conference, conducting a briefing or teaching, or having a management role in an organization at the team level or above.

T-2. Organizational design—Reflects experiences as in roles such as manager or above in organizational work, and specific experience related to evaluating, selecting, specifying, and assessing the benefits and value of systems and operations innovations in paid or volunteer positions held.

T-3. Communications—This component of the T-Top score considers many aspects of professional experience where communications are a prominent element of the activity. Written and verbal communication elements from professional life as reflected in publications, activities with professional organizations, involvement with committees in paid and voluntary organizations, teaching and conducting briefings, organizational roles including systems and operations innovation, leisure travel, ability to communicate in more than one language, and multidisciplinary and multicultural teams are included.

T-4. Critical thinking—Service in organizational leadership roles, developing written or oral presentations, completion of an earned academic degree, applications for awards or grants, providing mentoring or career guidance, and holding an executive position are contributors to this portion of the T-Top score. In addition, of course, your experience in each paid or voluntary position held in forming goals based on reason and evidence, forming systematic approaches to problem solving, being inquisitive, and prioritizing your efforts to dealing with problems in an orderly manner form the foundation for

this component. Additionally, critical thinking is enhanced in the T-Top score by your experiences in paid or voluntary systems operations roles.

T-5. Teamwork—This component of the T-Top score is enhanced by service in certain roles in professional organizations and conferences, manager and executive positions you have held in organizations you have been associated with (paid or unpaid), and team experiences you have had as a member of a work team in any professional context.

T-6. Networking—T-Top points for Networking are accumulated through participation in professional societies, editing a journal or a special issue of a journal, attending or speaking at professional meetings, or earning a degree in an additional field of study,

T-7. Empathy—The T-Top scoring for your ability to understand and share the feelings of another is assessed based on your membership in professional societies, some of your editorial roles on publications, earning a degree in an additional field of study, conducting briefings or teaching classes or workshops, managing a group of people in an organizational setting, mentoring activities, leisure travel, and experiences on multi-disciplinary and multicultural teams.

T-8. Perspective—Our overall perspective is influenced by most professional activities we engage in. The T-Top score reflecting perspective is based on your activities with professional organizations, publications, participation in professional meetings, as well as earning a degree. In addition, Teaching and organizational roles add to this score, along with experience in systems and operations innovations, ability to communicate in more than one language, leisure travel, and participation on multidisciplinary and multicultural teams.

T-9. Global understanding—Participation in national and international meetings, as well as speaking more than one language, leisure travel, and participation on multicultural teams are the

primary contributors to this final component of the T-Top score.

The MyT-Me score

Think of your resume or vita as the starting portion of your MyT-Me™ score. Each item that you enter from your work history, your educational past, your activities, and your roles is enhanced with specific features that relate to the T-Stem and T-Top scores. Each feature has its own weight and allocation in the system, so that as you enter information, the applied weights are summed into the scoring components. For example, as you record a particular job or volunteer role you have held, you'll also indicate when you began and ended that activity, your responsibility, and many other aspects of that activity that pertain to such things as your operational responsibilities, team activities, and your role in systems and operations innovations. As you describe your professional society memberships and roles, publications, projects, and other events in your professional past, the associated characterizations become part of the MyT-Me™ score.

Weights in the MyT-Me™ system for each activity are relative to each other, and are not anchored to any external feature. Hence, every MyT-Me™ score is comparable to other MyT-Me™ scores. A graphic display of your MyT-Me™ score is presented continuously as you enter information into the system. An example of this display is presented in the following Figure 11.2. The color scales for values are associated with the scores reported on the report.

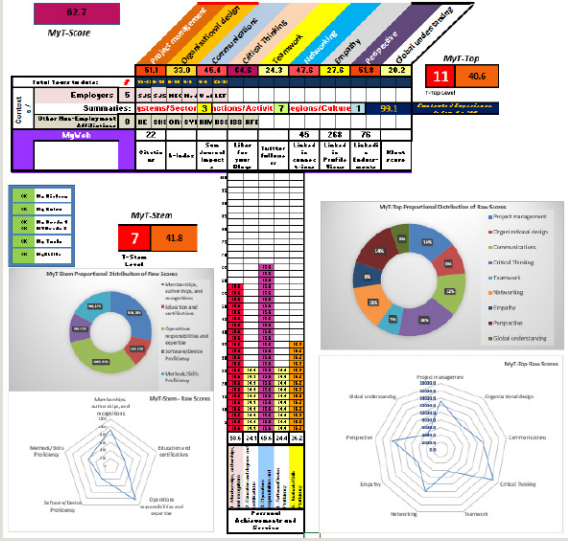

Figure 11.2 MyT-Me™ summary display

Other aspects of your background, reflecting the variety of industry sectors you have worked in, the variety of non-paid organizational roles you have held, and your WWW persona indices (Klout score, Likes, citations, etc.) are also reflected on this Excel report. Graphs simultaneously display the proportional allocation of your T-Top and T-Stem scores, as well as their raw score values in each T-Top and T-Stem assessment dimension.

Additional details about this system can be obtained from the author by writing to louis.freund@sjsu.edu

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The Future

More stakeholder perspective….

Context:

Government compliance and regulations,

Competitors and constant change, crime, and so on.

Collective Intelligence Perspective:

Teamwork and non-zero sum games as progress;

Value co-creation and capability co-elevation

Holistic Thinking Perspective:

Systems thinking, design thinking, service thinking,

Multidisciplinary thinking, Fadel 10 curves thinking

Socio-technical Systems Perspective:

Evolving ecology of nested, networked service system entities

Cognitive Systems Perspective:

People and their smart machines (cognitive mediators)

In the evolving service ecosystem

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CHAPTER 12

From "T" to "Π": The Other Leg That Systems Engineers Stand On

Nicole Hutchison[1], Art Pyster, and Devanandham Henry

Abstract

Systems engineers work with and often lead specialty engineers such as electrical, mechanical, and software engineers, as well as technologists, scientists, and all those skilled in the myriad of disciplines necessary to deliver systems. To do systems engineering well, organizations need effective systems engineers, those who consistently deliver value to their organizations. The Helix project has spent the last three years researching what makes systems engineers effective and how systems engineers can be made more effective (Pyster et al. 2015). Though Helix initially modeled the required skills of systems engineers outside of a T-model, with some alteration, the T-model is an appropriate and useful framework for examining the skill shape of effective systems engineers.

Context

The U.S. Department of Defense (DoD) and the Defense Industrial Base (DIB)—contractors that develop and deliver systems to the DoD—have been facing major systems engineering challenges in recent years (e.g., GAO 2012, 2013). Mission requirements are evolving and they demand ever more sophisticated and complex

systems (e.g., Boehm et al. 2010; Davidz 2006; Davidz and Nightingale 2007; INCOSE 2014); the tools, processes, and technologies that systems engineers must master keep changing more rapidly (e.g., Frank 2006); and budgets and schedules are being compressed dramatically.

Systems engineering is an interdisciplinary approach and means to enable the full life cycle of successful systems, including problem formulation, solution development, and operational sustainment and use that when done well can help address these problems. Systems engineers work with and often lead specialty engineers such as electrical, mechanical, and software engineers, as well as technologists, scientists, and all those skilled in the myriad of disciplines necessary to deliver systems. To do systems engineering well, organizations need effective systems engineers, those who consistently deliver value to their organizations. The Helix project has spent the last three years researching what makes systems engineers effective and how systems engineers can be made more effective (Pyster et al. 2015).

Organizations have responded to systems engineering workforce challenges in a variety of ways, such as offering extended training and education to their current workforce or systematically seeking to select specialty engineers with the potential to become systems engineers and incorporating them into the ranks of systems engineers. Unknown is whether these actions are producing the desired results because there is no common understanding of the diverse roles that systems engineers play, how they are selected and evaluated, which competencies are most important for different roles, how to evaluate effectiveness, or how experiences impact effectiveness. These and many other insights are critical to maintaining and growing the systems engineering workforce in the U.S. DoD and DIB.

The Helix Approach

In the first two years of the project, Helix primarily focused on data collection through semistructured in-person interviews with systems engineers, continually refining the interview questions and process. Follow-up interviews were conducted by telephone with most of the participants. During this time, participating organizations were from the U.S. DoD or the defense industrial base. Analysis of the data to address the Helix research questions offered insights into the effectiveness of systems engineers and led to the development of an early theory on the effectiveness of systems engineers, called Atlas 0.25. During 2015, Helix focused on validating and refining Atlas, in part by expanding data collection to non-DoD organizations and by interviewing the peers of systems engineers to validate what systems engineers believed were their primary values and contributions. During 2016, Helix has been focusing on implementation exercises with organizations, refining Atlas through lessons learned in practice; this will lead to a more mature version to be published in late 2016, Atlas 1.0.

Initially, the Helix project adopted a grounded theory methodology, not presupposing any specific theory or propose any hypotheses at the start of the project. Grounded theory was developed in the social sciences as a method for developing theory grounded in data that is systematically gathered and analyzed (Goulding 2002). Rather than beginning with a hypothesis, the first step was data collection. This approach is unusual in engineering research, where a researcher traditionally begins with a theoretical framework that he or she applies to the phenomenon to be studied. In the Helix project, the data collected from many semistructured interviews were marked up with codes that were grouped into concepts, that led to the identification of constructs and categories that formed the building blocks of Atlas. This approach minimized any bias that might be introduced by the researchers, instead allowing the large data set collected through the Helix project to drive theory development. Having established a preliminary theory of effective system engineers and proficiency model of systems engineers, data collection and interviews conducted during 2015 focused on

validating Atlas, and refining the theory toward developing Atlas 1.0 in 2016.

Atlas Results: Critical Skills for Systems Engineers

An overview of Atlas is illustrated in Figure 12.1. The main theme of Atlas is the definition of an effective systems engineer seen by following the diagram from the upper left corner around the edge to the bottom right corner: an Individual Systems Engineer who provides Consistent Delivery of Value is an Effective Systems Engineer. This definition hinges on Value, and as illustrated in the following, the Organization defines Value. The individual systems engineer provides Value by performing the Roles and Positions assigned by the Organization.

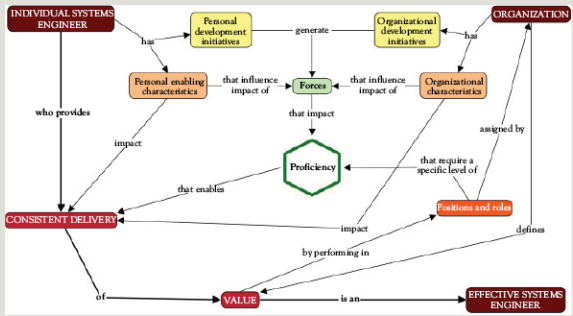

Figure 12.1 Atlas overview

The core of Atlas is the proficiency of the individual system engineer —the knowledge, skills, abilities, behaviors, and cognition. Proficiency is the key enabler for providing value and, therefore, effectiveness. Proficiency is impacted by Forces—the experiences, mentoring, and education and training an individual undergoes. The Individual Systems Engineer also has Personal Development Initiatives and can take advantage of Organizational Development Initiatives to improve proficiency. These initiatives generate Forces that impact Proficiency. At the same time, the Individual Systems Engineer has Personal Characteristics that influence the impact of Forces. Likewise, the Organization has Organizational

Characteristics that influence the impact of Forces. Further, both Personal Enabling Characteristics and organizational characteristics impact Consistent Delivery of Value. Amidst all these influences and impacts, the challenge for the individual systems engineer and the organization is to improve the Proficiency that enables Consistent Delivery of Value to the organization. A full description of all aspects of Atlas can be found in several Helix technical reports (Pyster et al. 2015a; Pyster et al. 2015b; Pyster et al. 2016).

The specific Proficiencies systems engineers require to deliver value are critical for understanding the effectiveness of systems engineers. The Atlas proficiency model consists of six proficiency areas based on the Helix interview data, as shown in Figure 12.2. Again, these are the critical skills required for systems engineers to be effective.

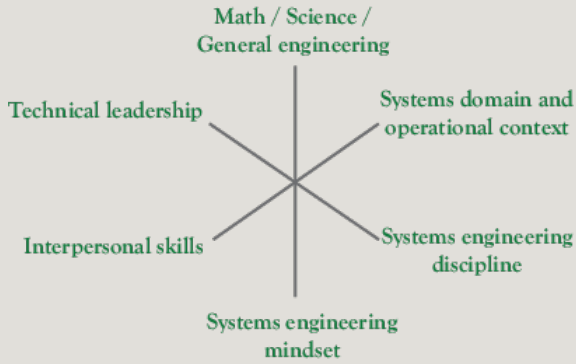

Figure 12.2 Proficiency areas for systems engineers

1. **Math/Science/General Engineering:** Math, science, and general engineering is a critical foundation for systems engineers. Interviewees provided specific recommendations based on what was needed for the particular systems they were developing or in their specific positions. For example, in an organization that focuses on aerospace systems, physics was highlighted as particularly important; system analysts discussed the importance of statistics; in the health care sector, biology and chemistry were more critical.

2. **System's Domain and Operational Context**: This proficiency area is heavily tied to the system(s) on which an individual is working. If that individual transitions to a new type of system, her proficiency level may change depending on familiarity with the new relevant domains, technologies, and disciplines.
3. **Systems Engineering Discipline**: This proficiency area contains the foundation of systems science and systems engineering-specific skill sets required in full-lifecycle development and management of systems, including systems engineering-specific tools, methods, and models.
4. **Systems Engineering Mindset**: This area is primarily focused on patterns of thinking, perceiving, and approaching a task that are particularly relevant to systems engineers. Aspects of each of these skills were mentioned in every interview. Almost every interviewee discussed the ability of a systems engineer to see "the big picture" as critical to providing value; engineers in specific disciplines are necessarily focused on details, but a systems engineer provides value by rising above that level and providing insight on potential pitfalls, areas of integration, and understanding the potential for emergence. These abilities were discussed as generally unique to systems engineers versus other types of engineers and most participants stated that they perceive this to be a "different way of thinking" than detailed engineers take. These skills directly contribute to the delivery of the values described previously.
5. **Interpersonal Skills**: Systems engineers do not work alone; they interact with people. As one interviewee stated, "Systems engineering is a contact sport." Irrespective of roles, a systems engineer is expected to be proficient in several interpersonal skills. While specialty engineers may be responsible for developing a specific aspect of the system, systems engineers are responsible for coordinating across all of these engineers. All interviewees agreed that interpersonal skills are more

critical to systems engineers than they are to specialty engineers.

6. **Technical Leadership**: "I believe that systems engineers are the ones who get all of the other engineers to work together," said one interviewee; "systems engineers tend to gravitate toward leadership," said another. It is common and natural for systems engineers to play leadership roles at many levels within an organization, and this aspect was discussed in almost every Helix interview. The specific categories included in this proficiency area include: building and orchestrating a diverse team; balancing decision making and risk taking; managing stakeholders and their needs; conflict resolution and barrier breaking; and business and project management skills.

Proficiency areas 1 to 3 may be considered to be the more "hard" or -technically based skills, while proficiency areas 4 to 6 may broadly be considered to be "soft skills." Development and evaluation of soft skills is addressed by the disciplines of psychology, social sciences, and management sciences. The six proficiency areas in Atlas are further divided into categories and, in some cases, into topics, as shown in Figure 12.3. Each of the proficiency areas is elaborated in the subsequent sections.

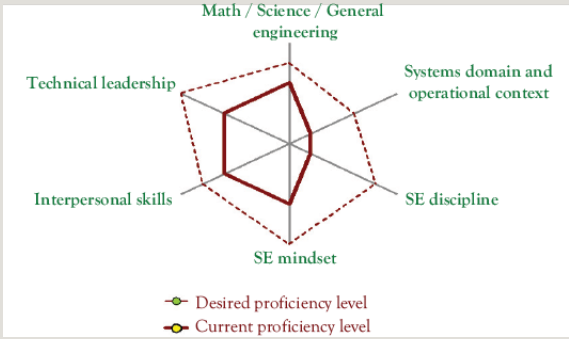

Figure 12.3 Example uses of proficiency profiles

The exact shape of a profile needed for a systems engineer to be

effective is dependent upon the position she holds—the roles she must perform and the values she is expected to provide. In addition, the types of systems and domains in which an individual works would influence the required proficiencies. For example, an individual working on financial systems would not need as high a proficiency in physics as an individual working on space systems. Figure 12.3 provides an example of how an individual could compare his current proficiency profile with the proficiencies required for a future position. The Atlas work could then give additional insights into how to change proficiency profiles.

Though the Helix study is specific to systems engineers, these results mirror parallel studies conducted in areas such as engineering innovation (Dutta 2015; Bement et al. 2015), business leadership (Wilson 2015; Waldawsky-Berger 2015), and higher education (Jackson-Hayes 2015; Seligo 2015; McCarthy 2015).

T-Shaped Skills

There are different perspectives on T-shaped skills models (e.g., Wladawsky-Berger 2015; August et al. 2010; Michigan State University 2014), but all share two main characteristics: a deep dive of skills in one area (the vertical of the "T") and a lighter covering of skills across many different areas (the horizontal of the "T"). The details—exactly how much depth, across how many disciplines—of what cross-cutting or multi-disciplinary aspects should be included, varies between models. One example provided by the T-Summit 2016 Conference (Michigan State University 2014) is shown in Figure 12.4.

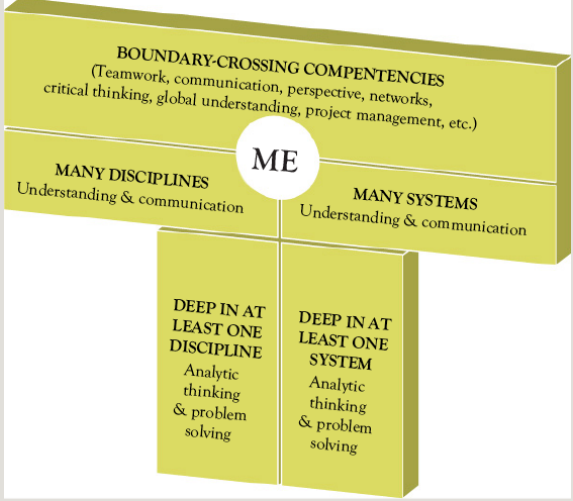

Figure 12.4 T-summit 2016 T-shaped skills model (Michigan State University 2014)

As discussed in the previous sections, systems engineers must be able to handle multiple systems and is interdisciplinary by nature. The T model in Figure 12.4 (Michigan State University 2014) refers to disciplines and systems. This means that the approaches that prepare individuals to become systems engineers—the types of experiences, mentoring, and educational approaches—are also relevant to learning to be more T-shaped.

Atlas Proficiencies Compared to T-Shaped Skills

A comparison of the T-shaped skills framework, such as that presented in Figure 12.4, to the Atlas proficiency model shows a good deal of overlap. However, fundamentally there are multiple spaces in which systems engineers require more depth than seen in the traditional "T" model. This is described in the following paragraphs and illustrated in Figure 12.5.

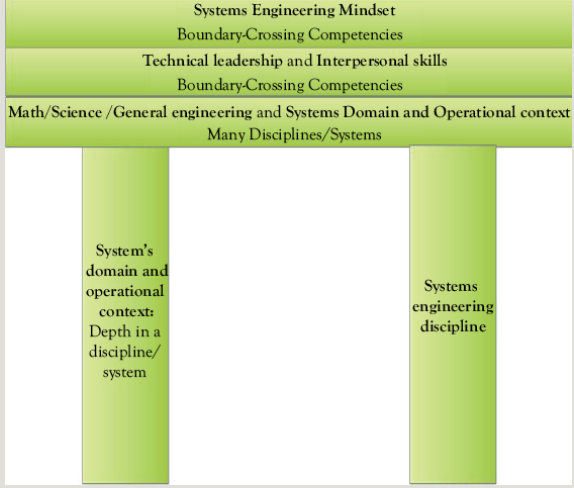

Figure 12.5 Atlas proficiencies: The Π (pi) model for systems engineers

- **Math/Science/General Engineering:** As a foundational concept, math, science, and general engineering concepts are critical for systems engineers. However, systems engineers function on teams with other engineers, technologists, or scientist. So while they must have working knowledge of these areas and be able to communicate across them, they do not require the same depth in them. In this way, these skills become a horizontal bar on the "T."
- **System's Domain and Operational Context**: Interestingly, systems engineers require both depth and breadth in this area. Usually depth in a particular type of system, technology, engineering discipline—providing them not only with some expertise but also clout within their teams—but also working knowledge across several of these areas in order to foster integration across a system. For these reasons, these skills appear as both horizontal and vertical bars on the "T."
- **Systems Engineering Discipline**: In additional to experiences and depth in foundational science and engineering disciplines and relevant technologies and

systems, a systems engineer must be skilled in the discipline of systems engineering itself. There is a full body of knowledge for the discipline and there are many methods, tools, and skills required to successfully develop systems and manage them from "cradle to grave." In this way, the discipline of systems engineering, itself an area of required depth, becomes a vertical bar on the "T."

- **Systems Engineering Mindset**: Big picture thinking and flexibility are the types of skills that characterize this proficiency area. Though clearly an individual can become more skilled in these areas (i.e., one can develop depth), these are the types of skills that cut across many different disciplines and domains and help integrate across multiple areas of concern. For this reason, while the most effective systems engineers are in fact highly skilled in this area, Systems Engineering Mindset is considered a horizontal on the "T."
- **Interpersonal Skills and Technical Leadership**: Communication, teamwork, and leadership are the kinds of cross-cutting skills that are critical for working in multidisciplinary teams. Again, these types of skills represent horizontals on the "T" model.

The horizontals are also different in that there are three. The model in Figure 12.4 implies that there are multiple disciplines in which a T-shaped professional should have some skill. But the types of skills highlighted in Atlas are different enough that they require some separation. Technical Leadership and Interpersonal Skills are analogous to the cross-cutting skills highlighted in many models. And the Math/Science/General Engineering and breadth-based System's Domain and Operational Context skills are analogous to the "many disciplines/many systems" categorization provided by the T-Summit. But the proficiency area of Systems Engineering Mindset is different from the other categorizations. While it can be considered a cross-cutting skill, it is also critical and was often cited by systems engineer's peers as a unique skill set that was highly valued within

their organizations. It differs from mere critical thinking to encompass systems thinking—thinking systematically and systemically—and paradoxical thinking—being able to understand and hold in opposition conflicting concepts simultaneously. This is a critical and unique skill set.

And as savvy readers will have noticed, and as Figure 12.5 illustrates, there were two primary areas of depth (horizontals) highlighted for systems engineers: both a depth in a technical domain (such as a critical discipline, technology, or specific system) is required as well as depth in the domain of systems engineering itself. It was repeatedly stated in the Helix interviews that a systems engineer must have both to be effective. Though the model presented in Figure 12.4 shows two vertical pillars, they are two analogous things: knowing a discipline or system. For systems engineers, that is not sufficient without also understanding the systems engineering discipline itself. For these reasons, systems engineers must be not just T-shaped professionals, but Π-shaped professionals.

Conclusions

T-shaped professionals have good communications skills to work across other disciplines, and systems engineers require similar communications skills across many technical disciplines, especially engineering to business/economics as well as the social sciences to address psychological or "people" aspects of systems. The Helix study initially began using a grounded theory approach, allowing the data to speak and determine the shape of results. The framework of T-shaped skills was not an initial input to the Helix study, but provides a useful way of examining and illustrating systems engineer's critical skills. Because of the nature of systems engineering, the "T" needs to be altered to adequately represent the skills of systems engineers. The Π-shaped skills profile will be a useful model for communicating the unique skills profile of systems engineers for workforce development and may provide a useful model for other professions that are, by definition, multidisciplinary.

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PART VI

How to Create 21st Century Professionals? T-shaped Adaptive Innovators

CHAPTER 13

Research-Driven Medical Education and Practice: A Case for T-Shaped Professionals

Nicholas M. Donofrio, Jim Spohrer[1], Hossein Seif Zadeh, and Haluk Demirkan

Abstract

T-Shaped Professionals have problem-solving (depth) and complex-communication (breadth) skills. The phrase originated in computer - education and then spread to other areas in part to create a contrast with traditional, highly specialized I-shaped professionals. Cataldo, Carley, and Argote (2001) vary the ratio of specialists (depth) and generalists (breadth) in simulations of organizations to study performance effects including total knowledge transferred. Levy and Murnane analyze job descriptions in the United States over a 30-year period and identify a trend toward increasing demand for expert thinking (depth) and complex communications (breadth). Collins and Evans study scientists and others to better understand models of expertise and identified the importance of both contributory (depth) and interactional (breadth) expertise. The demand for T-shaped professionals in knowledge-intensive service-oriented economies, especially in areas such as health care, is increasing. With an aging population in all developed and many developing countries demand for medical education is steadily increasing. The potential benefits of T-shaped professionals to organizational performance are quite

significant. Unfortunately, the challenges associated with creating more T-shaped professionals are also significant. National standards efforts for STEM (Science Technology Engineering Mathematics) education are beginning to move toward integrated curriculum to break down discipline silos. Service Science Management and Engineering (SSME) is an emerging discipline with over 250 programs in 50 nations seeking to create more T-shaped professionals. Future research directions aim to empirically demonstrate the benefits of T-Shaped Professionals in organizations as well as to develop improved approaches to the creation of T-Shaped Professionals.

Acknowledgments

We are grateful for the blog posts of two IBM colleagues, Keith Instone and David Ing, who explored the origins of the term T-Shaped Professionals.

Context

Deans at major universities know the problem all too well: There is too much for students to know, and too little time to teach it. Each year educators must decide what to drop to ensure time for the latest findings and forward-looking research topics. Furthermore, employers expect new hires both to hit the ground running and to maintain relevant new skills through lifelong learning—self-directed and on their own time. Welcome to the new world of education and practice in an era of accelerating change, and research-driven knowledge creation across all sectors of industry and society.

Medical education and practice will continue to be ground-zero in this storm for the foreseeable future. Demographic shifts to more aged populations in the world's wealthiest nations, all but ensure more research investments and more innovations. This viewpoint makes a case for T-shaped professionals. T-shaped professionals combine the benefits of deep problem-solving skills in one area, with broad complex-communication skills across many areas. As

knowledge growth continues unabated and technology augments both human problem solving and communications, this is one way forward that is coming into focus.

A case for T-shaped professionals in medicine is made as follows. First, relevant characteristics of research-driven medical education and practice are considered, expanding on the points mentioned previously. Second, the origins and arguments for T-Shaped Professionals in other areas, such as the fast-changing world of Information Technology (IT) and knowledge-intensive business services, is reviewed. Next, empirical data that go beyond the commonsense arguments used by advocates are summarized. Finally, a critical review is outlined, along with recommendations for future explorations that conclude with why this is a necessary, but difficult, change for medical and similar professionals.

Research-Driven Medicine

The growing gap between clinical practice, medical teaching and research is a cause for concern (Joyce, Piterman, and Wesselingh 2009). Many stakeholders agree that research must be even more closely connected with teaching as the rate of knowledge creation continues to increase. The coupling between practice and teaching is also an important consideration. “Because the clinical medical workforce is much larger than the medical education workforce, the contribution of clinicians to medical education in terms of total time spent is substantial. In 2006, clinicians provided almost three-quarters of total medical teaching hours” (Joyce, Piterman, and Wesselingh 2009). The three specialized roles, practitioner, educator, and researcher, must interact, or at least co-evolve more tightly and with closer synchronization. The number of people who engage in all three roles simultaneously is also growing; these people are also patients and often students, or at least lifelong learners.

The growth in number and diverse structure of new medical schools points to growing demand for medical specialists who dare to be

different, and creatively look beyond the well-established boundaries of the past (Lawson, Chew, and Van Der Weyden 2004).

The new schools are incorporating the recent reforms in medical education. All will provide curricula with problem-based, self-directed learning; horizontal integration between disciplines; vertical integration between basic and clinical sciences; early exposure to patients; and increased emphasis on communication skills, ethics, and personal and professional development. (Lawson, Chew, and Van Der Weyden 2004)

The context of accelerating change is not diminishing. "[W]e are beset by change—social, technological, scientific, economic; the list continues. These changes have affected all areas of life, including medicine, and the medical schools have had to respond" (Lawson, Armstrong, and Van Der Weyden 1998). Not only medicine, but all research-driven areas must respond. One response that seems to hold some promise is the creation of more T-shaped professionals—simultaneously possessing problem-solving (depth) and complex-communication (breadth) skills.

Origins and Advocates

While conversational usage is expected to be much earlier, the earliest known use of the phrase T-shaped people in print was in a 1991 London newspaper editorial. David Guest, responding to a report on jobs in computing, wrote:

This type of rounded personality is also sought in other branches of the same theory, which prizes individuals known as T-shaped People: These are a variation on Renaissance Man, equally comfortable with information systems, modern management techniques and the 12-tone scale. (Guests 1991)

Others at the time preferred the term hybrids:

The hunt for a new breed of computer manager is on. The British

Computer Society, in a controversial report published last year, described the quarry as a "hybrid" manager who would combine business expertise with IT skills. The hybrid manager, it said, would be distinguished by his or her ability to relate to "the broad picture" and to people, understanding their motivation and aspirations; he or she would also be energetic, intuitive, a good listener, and (cryptically) would have "an unusual set of interests." (Palmer 1990)

In the context of real-world R&D and complex systems, Harvard's Iansiti further popularized the term:

What follows is a typical profile for a successful integration team. In general, the members are the foundation of a system-focused approach to R&D. They possess a T-shaped combination of skills: they are not only experts in specific technical areas but also intimately acquainted with the potential systemic impact of their particular tasks. On the one hand, they have a deep knowledge of a discipline like ceramic materials engineering, represented by the vertical stroke of the T. On the other hand, these ceramic specialists also know how their discipline interacts with others, such as polymer processing—the T's horizontal top stroke. (Iansiti 1993)

Building on Iansiti observations, Leonard-Barton (1995) contributes the important connection to organizational incentives and the drawbacks of being T-shaped:

In most organizations, T-shaped skills are not created as a deliberate policy but emerge because individuals have been willing to risk a somewhat marginal career. Most formal organizational incentives encourage I-shaped skills—the deep functional experience represented by the T's stem. As a result, the individual is driven ever deeper into his or her expertise, which the organization continually draws on and rewards.

Do organizational cultures exist that might actually reward and encourage T-shaped people? According to Tim Brown, CEO of IDEO, top design firms do:

Recruiting T-Shaped People … We look for people who are so inquisitive about the world that they're willing to try to do what you do. We call them "T-shaped people." They have a principal skill that describes the vertical leg of the T—they're mechanical engineers or industrial designers. But they are so empathetic that they can branch out into other skills, such as anthropology, and do them as well. They are able to explore insights from many different perspectives and recognize patterns of behavior that point to a universal human need. (Brown 2005, 2009)

Advocates of T-shaped people often mention that the breadth of knowledge and experience enables faster adaptation and role changes, in addition to better communication skills for teamwork in multidisciplinary, multifunctional, or multicultural contexts. For example, Gartner uses the term "versatilist" noting:

Versatilists are people whose numerous roles, assignments and experiences are enabling them to synthesize knowledge and context to fuel business value. Versatilists are applying their depth of skills and experiences to a rich scope of situations and challenges and implementing their cross-organisational insight to flesh out teams and fill competency gaps. (Morello 2005)

For decades, IBM has advocated the need for more T-shaped professionals, especially in the areas of technology-driven business and organizational change. Since 2004, IBM has been working with universities, governments, and industry partners around the world to advocate a new discipline called Service Science Management and Engineering (SSME). SSME seeks to address the need for increased STEM (Science Technology Engineering and Math) education to meet industry's need for more research-driven service sector innovation (UK Royal Society 2009). SSME helps create T-shaped professionals who are better collaborative innovators (Donofrio, Calline, and Spohrer 2010) and adaptive innovators (IfM and IBM 2008) because of their deep problem solving skills in one area and broad communication skills across many other areas.

The number of advocates is increasing, and even includes those who see the benefits of T-shaped managers for next generation knowledge management (Hansen and Oetinger 2001), T-shaped philanthropists (Stannard-Stockton 2009), as well as the first T-shaped people consultancy service (broadeep 2009). Nevertheless, most advocates of the benefits of T-shaped people in organizations do so by advancing what are largely commonsense arguments that are based on anecdotal experiences. The next section introduces some preliminary empirical evidence in support of their claims.

Empirical Support

To date there is limited consensus on the definition of what a T-shaped person actually is and even less empirical evidence that supports the specific benefits claimed by advocates. Nevertheless, three different sources of evidence begin to lay a foundation for a precise definition and measurement method of the benefits of a larger ratio of T-shaped professionals in and across interconnected organizations.

What is "the right" ratio of generalists to specialists in an organization? This age-old question was put to the test using methods of computational organization theory develop by Kathleen Carley and her CMU colleagues (Cataldo, Carley, and Argote 2001). The overall results were perhaps not too surprising. Using a simple model of demand and altering the ratio of simulated generalists and specialists in an organization, this research efforts findings were well aligned with the following: (1) in the case of constant demand, organizational performance can be optimized using all specialists, but (2) in the case of variable demand, organizational performance can be enhanced by increasing the ratio of generalists that increases knowledge flows across the organization. Up to a point, the more demand varies, the higher the ratio of generalists is able to create performance benefits over alternative populations of strictly I-shaped specialist employees. Perhaps more important than the specific findings of these computational organization theory experiments is

the development of a method for lending more precision to the definition of people with different "shaped skills" and measures of performance benefits when demand and skills vary.

Is there evidence that supports the need for more T-shaped people at the national level? Using 30 years of economic trends related to job descriptions, MIT and Harvard economists Levy and Murnane examined how computers create and enhance some jobs, while eliminating and redistributing other jobs (Levy and Murnane 2004). The result is a clear trend in U.S. occupational structure with most job growth in higher-end, high-skilled occupations, and most job elimination in the lower-end low-skilled occupations. Their recommendation was to recognize this division and to prepare the population for the high-wage and high-skilled jobs that are rapidly growing in number—jobs that use computers and require extensive problem solving (depth) and interpersonal communication (breadth). Again, perhaps more important than the specific findings of this economic trend analysis study is the development of a method that could lead to a more precise definition of T-shaped skills needed to improve the performance of nations as a function of increasing computer capabilities (Collins and Kusch 1998).

Is there evidence that depth and breadth are useful dimensions for the scientific analysis of human competence and performance in domains as diverse as management, technology, and medicine? Sociology of science researchers Collins and Evans at UK Cardiff University have studied the nature of expertise across many scientific and other professions (Collins and Evans 2002). They conclude that professionals exhibit both interactional expertise (complex communications about what are the interesting problems to solve and methods to use) and contributory expertise (expert thinking and problem solving that leads to solving problems and creating new knowledge), and mastery of either requires interactions with other professionals with more experience. No amount of book learning alone is adequate. Full competence in both interactional and contributory expertise requires social interactions with more

experienced professionals.

While these three very different studies merely scratch the surface of what is needed to understand the costs and benefits of T-shaped professionals in organizations, nevertheless they provide converging evidence of the importance of this approach to conceptualizing expert performance in a domain. Each study clearly makes the case that the two primary dimensions of superior performance are complex communications (breadth) and problem solving (depth). These studies also make it clear that "the right" balance depends on environmental demands, the role and capabilities of technology, especially computer technology as augmentation for communications and problem solving (Engelbart 1980), and the nature of social interactions between professionals with different levels of experience.

Limitations and Critics

While advocates see more T-shaped professionals as urgently needed to improve performance in rapidly changing knowledge-intensive organizations and networks of organizations, the critics are not convinced. Perhaps the most damning criticism of the notion of "T-shaped" is simply that the notion adds nothing new. Critics are quick to point out that arguing for the importance of T-shaped people is like arguing for the importance of adults in society, or anyone with more experience. More experience is what is needed whether you call them T-shaped, I-shaped, or any other shape. All experiences have the potential to contribute to the breadth (communication skills), depth (problem solving skills), or other dimensions of professional practice. Other critics point out that since a diversity of types of experience and skill profiles will always exist in organizations, the concept of T-shaped could easily be misused to isolate and demean workers who play important roles, but who are not T-shaped.

For example, Bill Buxton recently and eloquently argued that

innovation calls for I-shaped people (Buxton 2009).

T-shaped is highly desired, but not sufficient. In staffing up teams, interview and test for I-shapedness. I don't care how good someone is either at the pragmatic or abstract level, there is someone out there who is equally good and who has strength at both ends. Find that person. If you doubt such people exist, just look at the profile of a reasonable sample of Nobel Prize winners. What I suggest you will find—based on having done so myself—is that a very high number share these combined T and I attributes. … the co-founder of IDEO, Bill Moggridge. He came up with the wonderful formulation of "T-shaped people." The vertical aspect of the T represents depth, and the horizontal bar is breadth. So a T-shaped person has basic literacy in a relatively broad domain of relevant knowledge along with real depth of competence in a much narrower domain.

Buxton's point, and the point of many others, is that it takes many shapes, and hiring is a search for the best shape for your organization.

Stepping back, one quickly realizes these arguments are not so much against, T-shaped skills as they are arguments in favor of a diversity of shapes including T-shaped. What about alternatives to T-shaped people that might improve organizational performance, adaptiveness, and be less costly to achieve?

For example, perhaps technology augmentation and a good knowledge base are better than human learning of knowledge that will be quickly out of date. It is hard for people to learn, but it is even harder for them to unlearn. Perhaps it is better not to internalize certain knowledge and rely instead on knowledge-based access to the required people and information. The trend toward a self-serve model of medicine is already well-established in certain areas, so that as patients adopt self-service, they will become mini-models of the technology-enabled professionals.

Perhaps a more fundamental argument is that specialist and

generalist are both needed, but not T's because they are too costly. Dash-shaped people would serve the important communication role, and I-shaped people would serve the important problem-solving role. This approach has the advantage that creating Dash-shaped and I-shaped people would be less costly than creating T-shaped people. However, what happens if the need for a particular type of I-shaped skill set goes away because of technological advances, or eradication of a disease or condition? Re-skilling of T-shapes is likely to be both less costly and less demoralizing to individuals, due to the fact that they already have some degree of interactional expertise in other areas.

Applicability to Medicine

A time-tested approach to the challenge of too much to know, and too little time to teach it, is proliferation of more categories of specialization of I-shaped people in each new knowledge silo. However, this solution evolved at a time when (1) change was slower, and specialization had value across a complete life span, and (2) information technology was relatively static across a complete human life span. Today, knowledge creation is not slowing down, but accelerating. The use of technology by professionals, and even by patients in a self-service model, is increasing. The diversity of health care related organizations networked together is also expanding. Given these trends, a case can be made for benefits of T-shaped professionals as a focus for medical education and a standard with medical practice.

First, it should not be surprising that the need for T-shaped people first arose in conjunction with computing professionals; the exponential rate of change in computing was given a name in the 1960's, in the form of Moore's Law. The trends associated with the growth of knowledge, technology, and organizations are not unique to computing or to medicine. IBM's Spohrer and Maglio lay a foundation for service science and the study of service systems with their own version of a generalized Moore's Law of improvement

(Spohrer and Maglio 2010). The traditional Moore's Law of computing is based on investing to create smaller and cheaper switches (e.g., transistors), but the generalized Moore's Law of service systems is based on investing to create more T-shaped people augmented or enabled by technology and organizations to create and harness the value of new knowledge. Knowledge in the minds and hands of T-shaped people enables more value co-creation interactions with others.

Second, as the planet gets smarter—more instrumented (from sensors to smart phones for monitoring health), interconnected (local and global epidemiological patterns can be pooled), and intelligent (algorithms help recognize patterns and suggest appropriate individual and collective responses)—multiple strands of empirical evidence support the need for T-shaped people with deep problem solving skills in one area (not giving up the benefits of I-shaped people) and better complex communications skills across many areas. On a smarter planet, quality of life continuously improves because of improvements in service systems and quality of service. Stanford's James March wrote about systems that learn to survive in increasingly dynamic environments adjusting to favor more knowledge creation (exploration) over simply using existing knowledge (exploitation) (March 1991). In modern business, investment to continuously improve resource allocation choice is known as a Run-Transform-Innovate, where exploration can either be transformation (copy the innovation of others) or innovation (invent the innovation others may copy).

Third, multidisciplinary teamwork is increasingly more prized; but to make teams work better, better complex communication skills are needed across discipline silos. Interdisciplinary programs, such as Professional Science Masters (PSM), Engineering Management, and others aim to create a greater integration of the study of science, engineering, and management.

The trend toward T-shaped professionals is becoming increasingly

clear, but the costs are also clear. T-shaped people are costlier to create, and traditional organizations (such as universities) have evolved to incent the creation of deeper and deeper I-shaped people, who are still very much needed. Recall the rise of T-shaped people does not mean the extinction of I-shaped people, only a change in the ratio for maximum performance in a changing world. Nevertheless, managing the cost is possible by harnessing advances in learning sciences, educational technologies, lifelong learning, and starting earlier with these ideas in primary education. These and other approaches suggest there is plenty of room for improving how much and how quickly people can learn, especially with better tools and organizational designs.

Educating more T-shaped people can improve the performance of multidisciplinary teams (which apply discipline knowledge) and interdisciplinary teams (which apply and create new knowledge), but it also sets the stage for true transdisciplinary thinking. Transdisciplinary thinking is perhaps as large a change (and investment) as when the United States decided that it was time for all citizens to have the right to a public education. Specialization has efficiency advantages (one person, one career), but for the U.S. society as a whole, a population with a general education is better prepared to adapt to change and is given greater freedom of choice in their careers. Freedom of career choice has real advantages for shaping a culture that aspires to limitless opportunities for all.

The folklore surrounding the early days of medical education can be summarized in the old adage: watch one, do one, teach one. Today, the new model may be: research it, practice it, and teach it. From a service science perspective, this corresponds to innovate a system, run the system (to further validate), and then transform other systems. With more T-shaped professionals, medicine may very well be able to keep up with the challenges of more to know and less time to (formally) teach it as it could continue to expand the “teaching” time for lifelong learners to enjoy the benefits of having access to greater knowledge.

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CHAPTER 14

Conclusions

In sum, the thinking about T-Shaped Professionals continues to evolve, and the case for educating T-Shaped Professionals continues to gather evidence in its favor (IFM and IBM 2008). The case for T-Shaped Professionals made in this book includes a wide range of perspective from chapter authors, including:

- Chapter 2: Heeren, Cornejo, and Lee (UTEC, Peru) discuss educating a new generation of holistic and global engineers, with broad professional and soft skills seamless integrated with deep technical skills to create T-Shaped Professionals.
- Chapter 3: Elden (MMCC, USA) explore creating a T-Shaped Mindset at the community college level in both students and faculty to encourage life-long learning, and the ensure the development of T-Shaped Professionals.
- Chapter 4: Markowitz (The Collective Mind) argues that creating T-Shaped Professionals requires massive change of both universities and industry, which are currently optimized to produce and hire I-Shaped Graduates.
- Chapter 5: Metcalf (Saybrook) and Umpleby (GWU) argue that universities are becoming more entrenched in producing I-Shaped Professionals as budgets are cut, and that T-Shaped Professionals will require more Systems Science at university, and more on-the-ground T-Shaped education programs by industry and government employers.
- Chapter 6: Evans and Hocker (Purdue Polytechnic Institute) describe on-going curriculum and assessment incubation and transformation required to create T-Shaped

Professionals at research-intensive universities.

- Chapter 7: Bertoline (Purdue) further explores needed transformations in higher education to produce a better-prepared STEM workforce of T-Shaped Professionals.
- Chapter 8: Grainger, Michaelis, and Mugge (NCSU) describe how managers can keep building T-Shaped Professionals once they are hired by providing a culture of innovation at work.
- Chapter 9: Korte, Husing, Dashja (Emprica GmbH) present a European Commission perspective on T-Shaped Professionals as adaptive innovators and e-leaders who are future ready employees.
- Chapter 10: Rowland and Hamilton (Ithaca College) share insights about developing empathy in T-Shaped Professionals who can fluidly take multiple viewpoints on challenges.
- Chapter 11: Louis Freund (SJSU) introduces a detailed framework for T-Shape Professionals to measure themselves, and thereby more systematically develop their MyT-Me scores.
- Chapter 12: Hutchinson, Pyster, and Henry (Stevens Institute of Technology) show that as T-Shaped Professionals develop thay can become Π-shaped, giving them another leg to stand on, especially design for system engineers.
- Chapter 13: Donofrio (IBM), Spohrer (IBM), Zadeh (-Australia), and Demirkan (U Washington) provide an argument in favor of research-driven medical education and practice.

Some of the authors mentioned previously consider the T-Shaped Professionals as a useful metaphor for talent and skills in a rapidly changing world that values collaborative, adaptive innovators. Other authors see T-Shaped Professionals as a measurable set of attributes

that can be formalized. People are complex and possess a wide range of capabilities, each of which could be plotted in some multidimensional space of capabilities. Mathematically speaking, these large number of data points that characterize the capabilities of a complex system can be projected on two dimensions, that could be labeled depth and breath.

The point is simply this—the performance of complex systems in an ever-changing, dynamic environment, whether they are individual people or organizations of even nations, must balance exploitation and exploration (March 1991). Exploitation involves solving known problems in routine ways, and exploration involves solving novel problems in innovative ways, often by learning from others. For individual learners, this balance is sometimes called "flow," or balancing routine and challenge (Csikszentmihalyi 2008). Too much routine may lead to boredom, and too much challenge may lead to anxiety. T-Shaped Professionals are adaptive innovators, life-long learners who are skilled in balancing routine and challenging activities, as well as communicating (collaborating) and thinking/doing (problem-solving).

Through a series of T-Summit conferences, the idea of T-Shaped Professionals has been debated, elaborated, and evolved (Spohrer 2018). In addition, the HICSS conference and AHFE HSSE conference have had tracks dedicated to further exploring and better defining the concept of T-Shaped Professionals as adaptive innovators. We invite others to join us on this journey.

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How to get involved

We hope you found this book thought provoking. If you would like to further advance your understanding of T-Shaped Professionals and continue the conversation on this topic, we invite you to join the - community of Adaptive T-shaped Innovators at the International Society of Service Innovation Professionals, ISSIP, www.issip.org.

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